POWER PLANT ENGINEERING

Established Over 28 Years

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Contents of this Issue

Methods of Operation at the Paterson Parchment Paper Co. Illustrated 932
Powdered Coal for Small Boiler Plants—I. By T. W. Atterbury. Illustrated 937
Maintenance of Piping System. By A. K. Vradenburgh. Illustrated 940
Traps Should Be Tested for Heat Loss. By George E. Gaster. Illustrated 942
Generating Steam from Waste Heat. By C. H. S. Tupholme. Illustrated 943
Calculating Steam Flow for Turbines. By J. Y. Dahlstrand. Illustrated 945
Economy Secured by Heating Feed Water. By C. E. Colborn. Illustrated 946
Buildings for Steam Power Plants 948
Interconnection of Electrical Systems. Illustrated 949
Operation of Converting Apparatus—II. By V. E. Johnson. Illustrated 952
Use of Slings for Heavy Parts. Illustrated 955
Skip Hoist Used Without Overhead Storage. Illustrated 957
Useful Oil Weight Chart. By W. F. Schaphorst. Illustrated 958
Loosely Drawn Contracts Invite Litigation 958
Summer and Winter Safety Hazards 959
Cleanliness Makes Boiler Room Attractive. Illustrated 960
Motor Drive for Ammonia Compressors. By Paul Schlingman. Illustrated 961
Cooling-Water Supply Important in Refrigeration. By A. W. Farrell. Illustrated 963
Makes Money from Ashes. By Sterling H. Bunnell. Illustrated 964
Prevention of Air Compressor Heating. By R. A. Cultra. Illustrated 965
Air Compressor Capacities and Pressures 967
Letters Direct from the Plant: Soda Ash as a Boiler Compound. Spare Motor to Drive Fan. Taking Chances. Repairing a Crosshead. Closet and Rack for Storing Gage Glasses. Oil Fouled Commutator. Mistakes in Textbooks. Illustrated 968
Questions and Answers: Air Lift Design. Length of Eccentric Rod on a Walschaert Valve Gear. Metering the Blow-off. Air Chamber Capacity for Pump. Paint for Use in Oil Tanks. Heating Surface Required for Dry Kiln. Illustrated 971
Editorial Comment: If Winter Comes. Sketches and Notes Are Important. Asking Questions. Keep Everlastingly at It. Bring Out the Torches—the Parade Is on 974
Off Duty 975
Double-Acting Diesel Engine Brought Out. Illustrated 976
Bent Tubes Facilitate Cracking Scale in Evaporator. Illustrated 978
Multiple Exhaust Blading Used in English Turbine. Illustrated 978
Centrifugal Sump Pump Operates Automatically. Illustrated 979
Plant Construction Being Rushed in California 979
Small Air Compressor for Portable Use. Illustrated 979
Disc and Seat Are Reversible in New Valve. Illustrated 981
Plates Held by Springs in New Air Preheater. Illustrated 980
News Notes 981
Books and Catalogs 982

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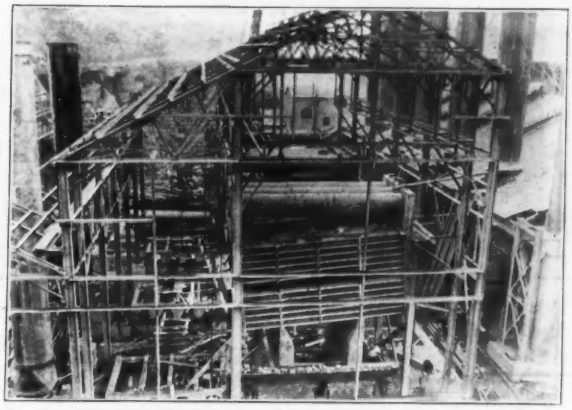
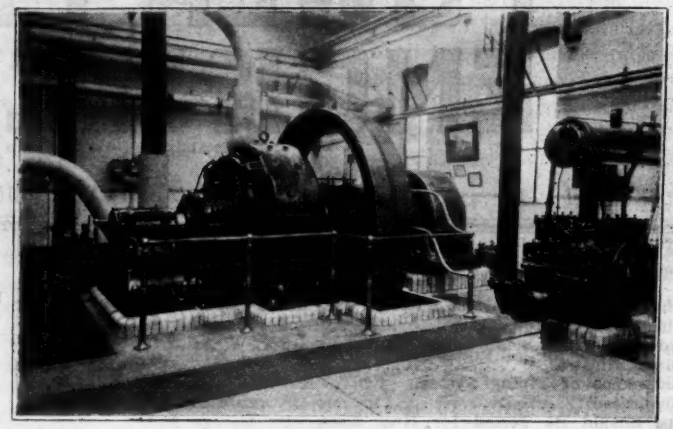


When Boilers Act as Beggars

ONE GLANCE at the above picture and it is apparent that the designer did not provide either a coal bunker or a boiler furnace; still these boilers are expected to deliver steam. This sounds as though perpetual motion theories had actually been put into practice. In reality this picture is a view of American practice in waste heat reclamation. These boilers will produce steam without a penny being spent for fuel. They are reclaiming, from what would otherwise be waste gas, 380,000 B.t.u. for each 100 lb. of coal which must be burned in industrial furnaces. This is the equivalent of producing steam free of charge as far as steam producing coal is concerned; or if the boilers are charged with some of the coal burned in the industrial furnaces it is equivalent to reducing the furnace fuel bill by 25 to 30 per cent. In an article in this issue by Mr. Tupholme will be found data on recent English practice in waste heat boiler engineering.

GETTING DOWN to earth is quite commonly the necessary trend in the development of an industrial process. First applications are frequently so big that they are out of the reach of ordinary common practice. Dividing the arc lamp was one of the big problems in electrical engineering. Engineers are still working on the problem of mechanical stokers for small boilers. Until recently pulverized coal has been considered economical only in real large boiler plants but the trend toward use in plants of average size has started, as will be noted in the article by Mr. Atterbury on page 937 which is the first of a series dealing with the use of powdered coal in small plants.



Methods of Operation at the Paterson Parchment Paper Co.

Operation of Passaic, N. J., Plant Is Characterized By Engineering Qualities of High Excellence

OPERATING A POWER plant can be either one of two things. It can be merely a job—a means to an end, or it can be one of the most interesting games a man can play. Which of these it is in any particular case depends largely upon the individual concerned.

Whether an engineer in charge of a plant considers his work a job or a game can be judged largely from the appearance and general atmosphere of his plant. If he views it merely as a job—drudgery, the chances are that the appearance of the plant and the morale of the employes will reflect this attitude. The equipment will not be kept in the best condition and operations will be conducted in a more or less haphazard manner. The employes will display no enthusiasm. Lack of interest on the part of the chief will certainly not encourage the employes to exert any unusual degree of effort.

If, on the other hand, the chief is enthusiastic about his work, if he considers it as an interesting game wherein he and the men under his charge are all on one side and where their opponents are inefficiency, high operating costs and unnecessary labor, the plant will probably be in the best of condition and an atmosphere of geniality will prevail.

No visitor to the power plant of the Paterson Parchment Paper Co. at Passaic, N. J., will be in doubt long as to which of these conditions prevails there. The spic and span appearance of the plant, the absence of confusion, the spirit of cordiality among the operators and their whole hearted interest in their work, all bespeak efficiency and successful cooperative effort.

The plant itself is not a show place. Like many others of its type it is the result of a gradual growth from a small beginning to a plant of moderate proportions and its layout therefore is not as symmetrical as it might be if it were a new plant. The buildings are not as spacious and airy as those of our more modern stations and some of the equipment is spaced closer than might be desirable, but these facts in no way detract from the high quality of engineering characteristic of this plant, in fact, they serve to emphasize its excellence to an additional degree.

This plant, which furnishes all the power, light and heat necessary for the operation of the Passaic plant of the Paterson Parchment Paper Co., is located centrally with respect to a group of factory buildings and consists of a boiler house, engine room and coal storage bunkers together with such associated equipment as coal handling apparatus, water tanks, etc. An exterior view of the plant is shown in the photograph at the head of this article. The radial brick stack shown on this photograph is 200 ft. in height.

In discussing the operating features of this plant we will begin with the delivery of coal to the plant and follow its progress through the plant as it is converted into electric power and heat.

Methods of Determining Coal Consumption

Coal used at this plant is of a low grade, running about 11,000 to 12,000 B.t.u. per lb., 20 per cent ash content and from 10 to 12½ per cent moisture. It is known locally as a barley and bird's-eye mixture. In addition to this poor coal which is ordinarily used, a small supply of good bituminous is kept on hand to be used in times of emergency. If the load on the boilers should suddenly increase to such an extent that the firemen could no longer maintain the fires with the poor coal used, a few wheelbarrows of the good bituminous can be wheeled in quickly and thrown on the stokers by hand. This procedure is rarely

necessary but it does happen occasionally and it is for these rare occasions that this supply of good coal is kept on hand.

Careful record is kept of all coal received as well as that used under the boilers each day. This information is submitted to the chief engineer in the form of a weekly coal report, a sample of which is shown in Fig. 6. This form, it will be noted, lists the total quantity of coal used during the week by each boiler and also the number of cars of new coal received. An average sample of each week's coal receipts is sent to the plant laboratory for analysis. Figures for the heat value and moisture and ash content are used in determining the overall efficiency of the plant.

Coal brought to the plant may be delivered directly to the overhead bunkers in the boiler room or it may be stored in a large concrete bin in the yard outside the plant. This bin is of modern design and is constructed with a garage underneath. It can be seen just back of the water tower in the exterior view of the plant at the head of this article. The capacity of the coal handling apparatus, which consists of Link-Belt scraper conveyors and Robins belt conveyors, is about two cars or 100 T. an hour. The concrete storage bin holds approximately 125 cars. A view of the scraper conveyor is shown in Fig. 3.

A Link-Belt coal crusher is provided but this is not used ordinarily as the coal is sufficiently fine to permit of its being burned as delivered.

Richardson automatic coal scales installed on each boiler furnish an accurate means of determining the coal burned under the boilers. The coal scales are tested for accuracy every morning, and readings are taken every 8 hr. These readings supply the information contained in the upper half of the weekl coal report previously referred to.

Ash is taken from the hoppers in the basement, and by means of ash cars is delivered to an elevated steel tank by an R. H. Beaumont Co. electrically operated skip hoist. There is a considerable demand for ashes for filling purposes in the vicinity of the plant and all ash is sold.

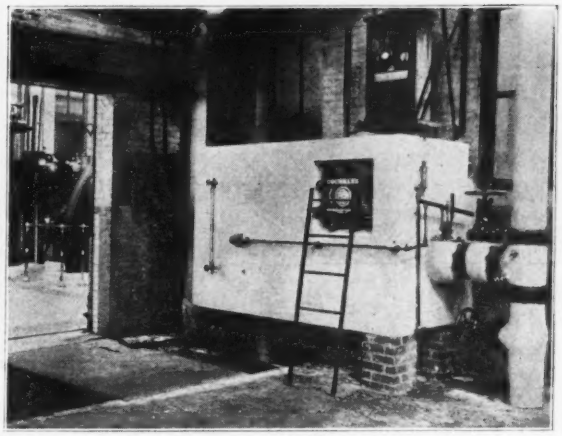


FIG. 1. ALL FEED WATER IS MEASURED BY THIS V-NOTCH METER

Boiler Operation

Steam is generated in three longitudinal drum, Babcock and Wilcox boilers rated at 600 hp. each and equipped with Coxe chain grate stokers. Each boiler has 294 four-inch tubes, 18 ft. long and three steam drums, 42 in. in diameter. The stokers are driven by General Electric direct current motors controlled by variable speed drum controllers located in the firing aisle.

Boilers are supplied with forced draft by two engine driven Sturtevant fans each of which has a capacity of approximately 50,000 cu. ft. per min. against 3 in. static pressure. These fans operate at practically constant speed and are hand controlled. Draft to the boilers, however, is regulated by means of the Engineer Co., system of balanced draft. Draft pressures in various parts of the boiler

FIG. 2. A FEW OF THE RECORDING INSTRUMENTS INSTALLED IN THE BOILER ROOM

FIG. 3. COAL IS DELIVERED TO THE OVERHEAD BUNKERS BY MEANS OF A SCRAPER CONVEYOR

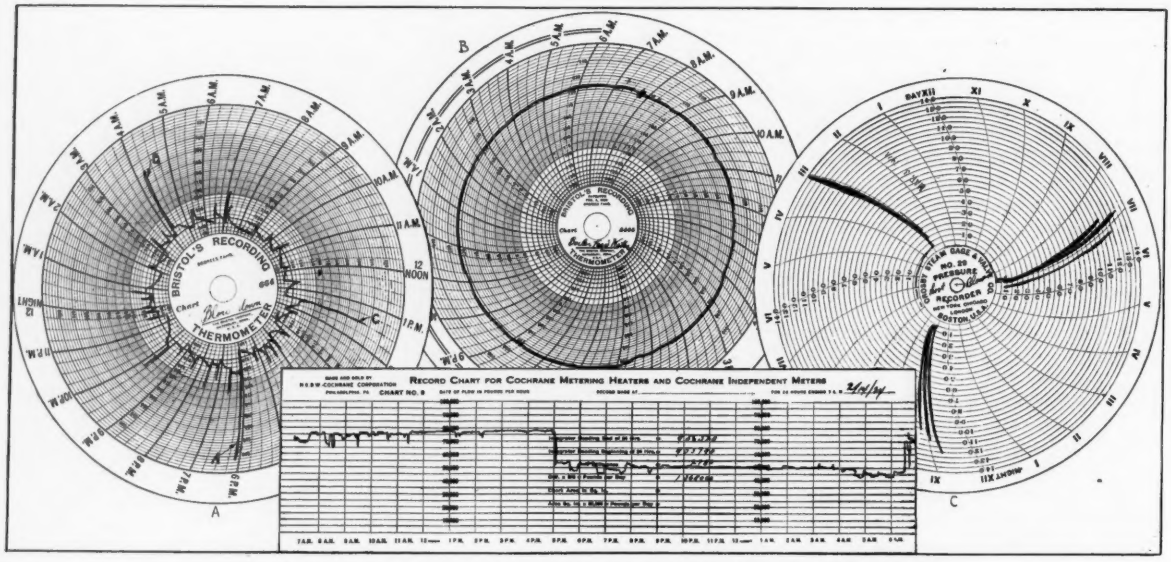


FIG. 4. TYPICAL CHARTS FROM SOME OF THE RECORDING INSTRUMENTS

(a) Chart showing blowoff operation.
(b) Feed water temperature.
(c) Soot blower operation.
(d) Chart from the V-notch meter.

and gas passages are indicated by Precision 5-in-1 gages. Pressures maintained ordinarily are as follows:

Draft Pressure in ash pit	1.5	to 2.0	in.
Draft Pressure above grates	0.0		
Draft Pressure, 1st pass	1.5	to 2.0	in.
Draft Pressure, 2nd pass	1.0	to 1.25	in.
Draft Pressure, 3rd pass	0.8	to 1.0	in.
Draft Pressure, last pass	0.03		in.

As to combustion conditions, a careful watch is kept at all times and there is provided an ample array of indicating and recording instruments for determining these conditions. A few of these instruments may be seen in Fig. 2. Mono recorders are provided on each boiler for recording both the CO and the CO_2 content of the flue gas. The CO_2 is usually maintained at approximately 12 to 13 per cent.

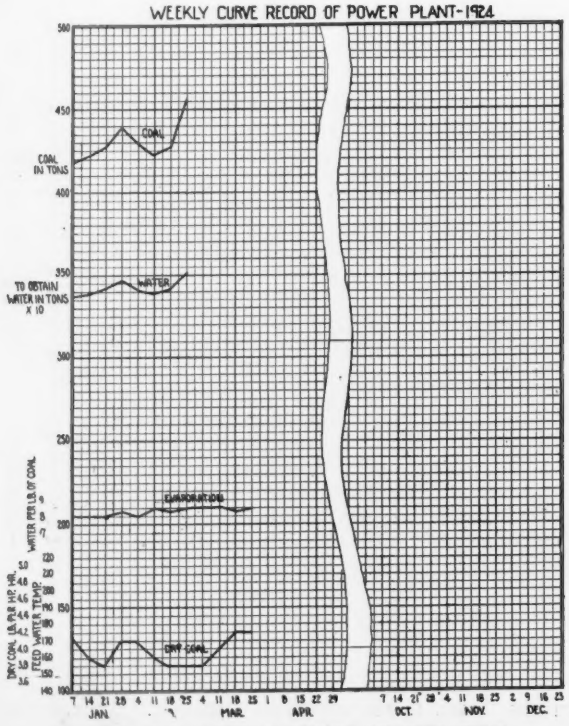


FIG. 5. THE ANNUAL RECORD OF OPERATION

General Electric Co. steam flow meters are installed on each boiler header as well as on each steam supply line to the various departments in the factory. These flow meters together with the V-notch meter in the feed line to be mentioned later furnish a double check upon the total quantity of water evaporated.

Bristol indicating and recording thermometers and pyrometers are installed on the boilers to aid in determining the state of cleanliness of the boiler surfaces and for testing the conditions of the settings. These are used mainly for measuring the temperatures of the gas in the stack and uptakes.

All these instruments, including also the boiler steam gages, are located in the firing aisle in full view of the firemen so that they are at all times kept informed as to what is going on inside the furnaces. This, in the chief engineer, H. B. Harmsen's opinion is one of the most important functions of any instrument—to keep the operator informed as to conditions inside the boilers and furnaces. Of course, instruments have a decided value in recording and putting into permanent form operating information of value to the chief engineer, but this is perhaps, of less importance than the value of the instrument to the operators as a guide in performing their work.

An instrument placed in the boiler room merely to check the fireman's work is of less value than no instrument at all, for he soon comes to regard it as a spy and will treat it accordingly.

Feed water is usually obtained from the city mains, although in case of emergency feed water may be taken from either of five different sources, including a number of deep well pumps. All returns from the heating system are used as well as the condensate from the surface con-

denser of one of the engines. Since only one of the three engines installed operates condensing, a considerable quantity of make-up must be supplied.

Raw water is treated by means of a Cochrane hot process softening system installed in the boiler room. This system is capable of treating 114,000 lb. of water per hr., and uses approximately 1 lb. of caustic for every 25,000 lb. of water. The amount of water treated daily amounts to 1,275,000 lb.

Water to the boilers is first heated in an open heater on top of the softening tank to a temperature of 220 deg. After treatment it passes through the Cochrane V-notch meter shown in Fig. 1 then through the boiler feed pump and finally through a closed Alberger heater where the temperature is again raised to about 220 deg. (the temperature having dropped 4 to 6 deg. in passing through the V-notch meter). Both open and closed heaters are supplied with exhaust steam from the engines. A chart showing the temperature of the boiler feed water just previous to its delivery to the boilers is shown in Fig. 4B.

There are three boiler feed pumps, two of which are used alternately, one one week and the other the next, and the third one is kept as a spare unit. All of these feed pumps are Dean Bros. outside packed plunger pumps.

Engine Equipment

In the engine room there is installed, one 500-hp. cross-compound Hewes and Phillips non-condensing engine and one 500-hp. Skinner Universal Unaflow non-condensing engine, both driving direct current generators. There is also installed a Chicago Pneumatic Tool Co. steam-driven air compressor.

In addition to the equipment listed above installed in the engine room, there is installed in other parts of the plant the following apparatus:

One Laidlaw-Dunn-Gordon air compressor, size 15 by 9 by 12 in., direct connected to a 75-hp. motor.

One Ball engine connected to a 20-kw. generator.

One 75-hp. Skinner engine belt connected to a 50-kw. generator.

The last two units mentioned are kept only as spares for emergency operation.

COAL REPORT

FOR WEEK ENDING March 29. 1924

	SCALE READING LAST WEEK	SCALE READING THIS WEEK	COAL WEIGHED LBS ANTHRACITE	BITUMINOUS
No 1	167595	171099	350400 lb.	
No 2	503832	507093	316100	
No 3	701635	707352	566700	
No 4				
USED IN BOILER HOUSE No 2			1233200 lb.	616 tons 1200 lb.

COAL RECEIVED DURING WEEK 14 Cars

DATE	CAR INITIAL	CAR NUMBER	GRADE	ANTHRACITE	BITUMINOUS
3-22	Erie	32372	Barley	✓ Thos R	
3-24	D & H	10112	B Eye	✓ Stoker	
	D & H	27026	#3 Buck	✓ Stoker	
3-25	Erie	43081	Barley	✓ Thos R	
	D & H	28670	#3 Buck	✓ Stoker	
	D & H	26572	"	✓ "	
	D & H	44768	"	✓ "	
3-26	Erie	57649	Barley	✓ Thos R	
3-27	L & S R R	8129	"	✓ R R	
3-28	D & H	25600	B Eye	✓ Stoker	
	D & H	41019	#3 Buck	✓ "	
	D & H	23283	"	✓ "	
	Erie	27226	Barley	✓ Thos R	
	Erie	27212	"	✓ "	

FIG. 6. A COAL REPORT IS SUBMITTED WEEKLY

One 500-hp. cross compound Hewes and Phillips condensing engine direct connected of a direct current generator.

Details of Maintenance and Operation

The plant is operated on a basis of three shifts of 8 hr. each. In addition to the chief and first assistant engineer the day shift is made up as follows:

One man and helper in the boiler room for taking care of all boilers and removal of ashes.

Two men taking care of coal, that is, in emptying incoming coal cars.

BOILER ROOM Week Ending 192

TIME	FIREMAN	COAL SCALE READING Boiler #1	Boiler #2	Boiler #3	Total Coal Burned in 24 Hours	Total Lbs of Water Evaporated in 24 Hours	Lbs. Water per Lb. Coal	Temperatures Outside	Feed Water	Stack	CO² 1	2	3	Ave.	Average Steam Pressure	Draft Gauges Boiler No. 1	Boiler No. 2	Boiler No. 3	Flow Meters Boiler #1	Boiler #2	Boiler #3	Acid Plant	Soot Cochran Gauge to Cond.	Blow Down	Boilers Blow Down	Gage Glass
																L P D F 1 2 3	L P D F 1 2 3	L P D F 1 2 3								

ENGINE ROOM Week Ending 192

TIME	Gauge Press.	Rec.	Vac.	R. P. M.	Lbs. Steam	Lbs. Steam per H. P. per Hr.	Amp.	Voltage	Hp. Hours Power	Watts	Night Engine Amp.	Voltage	REMARKS

REMARKS:

FIG. 7. BOILER AND ENGINE ROOM LOG SHEETS

FIG. 9. CHARTS AND REPORTS ARE CAREFULLY GONE OVER BY THE CHIEF ENGINEER

One man as a general utility man who keeps the boiler house in good shape.

One oiler and helper in the engine room. At night the operating force consists of an engineer, a fireman and a helper. The shifts are divided as follows:

Day shift..... 7 a. m. to 3 p. m.
Evening shift..... 3 p. m. to 11 p. m.
Night shift.....11 p. m. to 7 a. m.

Ordinarily, during the summer months, two boilers operating at from 175 to 200 per cent rating are able to carry the load without any difficulty and one boiler is shut down. In winter, however, when the load is heavy it is necessary to use all three boilers.

Boilers are subject to a rigid system of inspection and maintenance, being taken off the line and overhauled every three weeks. At this time the tubes and headers are carefully examined, the brickwork inspected and repaired if found damaged, the stokers are overhauled and everything is given a thorough cleaning. Each boiler is given an hydrostatic test once a year.

Each boiler has three 4-in. safety valves which are tested by hand once each day and are popped off by pressure once a week.

Water columns are blown every hour and one of the three boilers is blown down on every shift. In this connection it may be interesting to explain the method of recording the blow-down operations.

A recording thermometer bulb is permanently installed in one end of the blowoff line, that is, in the end of the blowoff line opposite to that which leads into the blowoff tank. Ordinarily, the recorder pen traces a smooth line. When a boiler or water column is blown down, however, the temperature in the blowoff line suddenly increases and the recorder pen traces a vertical line, the height of which is proportional to the temperature. The temperature attained at the thermometer bulb, however, is not the same for all boilers and for the various water columns. The temperature produced by the blowing down of the boiler whose blowoff line is connected nearest to the thermometer bulb will naturally be higher than that produced in blowing down the boiler farthest away from the bulb, and the lines recorded on the chart will be of different heights. This then furnishes a means of recording not only the exact times of blowing down but also indicates just what boilers are blown down.

FIG. 10. A VIEW IN THE BOILER ROOM

For recording operation of the Diamond soot blowers installed on each of the boilers, a similar method is used.

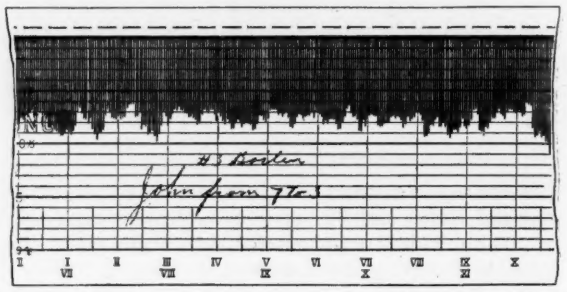


FIG. 8. THE CO_2 IS MAINTAINED AT APPROXIMATELY 12 TO 13 PER CENT

In this case, however, a recording pressure gage is connected to the soot blower line so that whenever the soot blowers are operated, the rise in pressure will be recorded. A chart taken on this recorder is shown in Fig. 4C. The soot blowers on each boiler, it will be noted, are operated once each shift.

All water tests are made in the chief engineer's office by the shift engineer. Water is tested every 2 hr. for hardness. The result of these hardness tests serve to determine the amount of chemical to be added in softening.

All instrument readings and operating data are averaged once a day and these averages form the basis for the weekly average. The efficiency of the plant is figured each day and a continuous study of operation maintained. A complete record of operation is kept in the form of a chart which contains the weekly averages for a period of one year. This chart shows the amount of dry coal used per hour, the feed water temperature, the number of pounds of water evaporated per pound of coal used, the total quantity of water used in tons, and the total amount of coal used in tons.

Once a week a meeting is held of the boiler and engine room force where all points concerning operating are discussed and settled. These meetings have done much to make for better feeling and better co-operation among the employes.

In closing this article, we wish to acknowledge our indebtedness to R. T. Anderson, assistant general manager of the Paterson Parchment Paper Co. and to Henry B. Harmsen, chief engineer of the plant, for courtesies extended and privileges accorded in gathering the information used in the preparation of this article.

Powdered Coal for Small Boiler Plants*---I.

UNIT PULVERIZING SYSTEM MAKES POWDERED COAL AN ECONOMICAL FUEL FOR PLANT WITH FEW BOILERS. BY T. W. ATTERBURY

MUCH has been written on large boiler installations now being fired with pulverized coal and it is frequently stated and generally accepted that a plant of less than 2500 developed boiler horsepower on a 24-hr. operating basis should not consider using pulverized coal. The reason given for the foregoing statement is that the cost of installation of the coal preparation plant and the labor required for operating it, is too high to make the installation a profitable investment. This may be true when the boilers are fired with coal prepared and delivered from a central preparation plant to a small number of boilers but a simple and profitable installation can be made to a small number of boilers by adopting what is called the unit pulverizer method of pulverizing and firing.

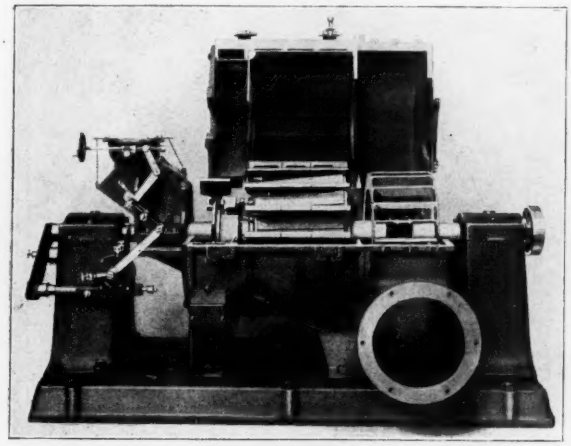


FIG. 1. UNIT PULVERIZER BEATS SLACK TO POWDER AND BLOWS IT INTO FURNACE

UNIT PULVERIZERS

This is a self-contained machine which is placed adjacent to, or directly in front of the boiler to be fired. The machine usually has a number of beaters revolving at a high rate of speed, which pulverize the slack coal to the necessary fineness. From the beater chamber the fine coal only is drawn by an exhauster and blown directly into the combustion chamber of the boiler where it is ignited, the gases of combustion passing through the boiler in the usual way, except that the combustion chamber is larger than hand fired or stoker practice.

Direct motor drive is usually employed with the unit pulverizer, the whole making a compact self-contained unit, hence the name "unit pulverizer." No preliminary drying of the coal is necessary. There is usually a reduction in the moisture content of the coal when being pulverized, where about 3 to 5 per cent of the free moisture is removed and carried off with the air. Coal with a moisture content of from 10 to 15 per cent has been put through this type of pulverizer and successfully burned and it is possible in an emergency to pulverize and burn coal with a much higher moisture content than 15 per cent.

*This is the first of a series of three articles on this subject, the second article will appear in the October 1 issue.

Such a unit pulverizer is a fuel regulator, a pulverizer and a furnace feeder all in one. It has the further advantage of supplying the necessary air for combustion. The outstanding advantages of the unit pulverizer are the small space occupied and the small initial cost.

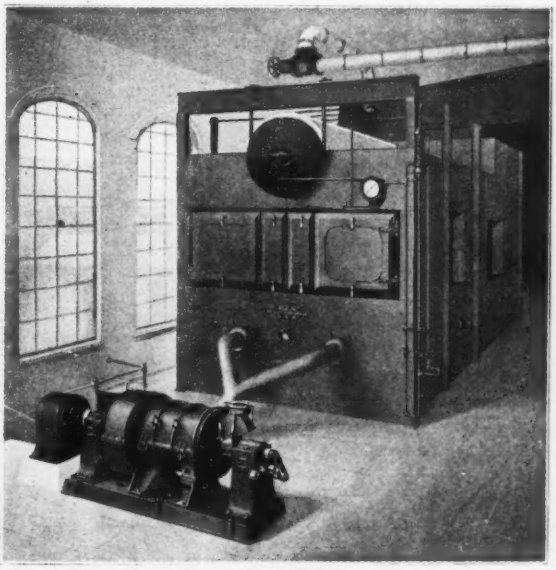


FIG. 2. THIS ARRANGEMENT OF PULVERIZER AND BOILER IS CONVENIENT FOR ATTENDANCE

Figure 1 is a cross section of one type of horizontal pulverizer showing the pulverizer alone, and having a coupling on the shaft for direct motor drive.

Figure 2 is an illustration of the same pulverizer located in front of the boiler and firing direct into the combustion chamber.

Where a high moisture coal is used, heated air around 350 to 400 deg. F. can be passed through the machine in order to evaporate the water from the coal and to leave the pulverized coal relatively dry.

For instance, coal of 20 per cent moisture can be pulverized and fired to the boiler carrying only 3 per cent moisture. The water evaporated is passed along into the combustion chamber with the coal and air and is converted into superheated steam.

There is no thermal gain by doing this; the advantage is that dry coal can be conveyed and ignited better than coal with a high moisture content.

Pulverizers now on the market vary in capacity from 1000 to 6000 lb. per hr. and there are four or five different sizes. The power consumption per ton of coal pulverized is 21 kw.-hr. with the coal containing 5 or 6 per cent moisture and grinding to 85 per cent through a 200-mesh screen. The power consumption will vary with the moisture content and fineness pulverized. This will be referred to later in this article.

Most types of unit pulverizers have a pocket in the casing where the tramp iron is collected and removed periodically. Small pieces of iron do not appear to be

harmful to the machine. Where a number of units are used in a boiler house, it is good policy and sound engineering to install a magnetic separator and prevent the iron getting into the coal hoppers.

The space taken up by a machine 6000 lb. capacity per hour would be approximately 5 ft. wide by 10 ft. long by 7 ft. high and weigh with bedplate and motor, 20,000 lb. This is for a horizontal machine. A vertical type pulverizer would require less space.

To figure the size or capacity of a unit pulverizer required, the coal consumption per hour can be estimated as follows:

Say boiler is 350 hp. at rating, and is operated at 200 per cent of rating, the coal available having a B.t.u. value of 14,000, boiler efficiency required being 80 per cent.

$$\frac{34.5 \times 970.4}{14{,}000 \times 0.80} \times (2 \times 350) = 2092 \text{ lb. of coal per hour,}$$

or approximately 2100 lb. to be fired per hour.

In order to have ample pulverizer capacity to take care of a lower grade of coal, or a wet coal, we would select a pulverizer of 3000 lb. maximum capacity per hour.

Central Preparation Plant

This is made up of a number of units consisting of receiving, drying, pulverizing and conveying equipment, to carry the coal to point of use. A diagrammatic illustration is given in Fig. 3, when by comparing with unit pulverizer shown in Fig. 1 the difference in first cost is accounted for.

In making this comparison the track hopper and bucket elevator for handling the raw slack coal will be required for both systems where the tonnage of coal burned per day is more than can be handled by wheelbarrows, or by a crane or other convenient method.

When changing from hand or stoker fired to pulverized coal firing, the question of cost is important. The engineer and owner may note the simplicity of operation, the improvement in labor conditions, increased flexibility of the coal supply owing to possibility of burning practically any grade of coal but the question to be answered is—will this proposed change pay for itself, and how soon?

When estimating the cost and type of equipment to be recommended, local conditions must be known, including the number and size of the boilers to be equipped. Where the daily coal consumption is low, say 20 T. of coal per 12 hr. or less, the unit pulverizer is generally the most profitable investment. A boiler house with a daily consumption of 75 to 100 T. of coal per day may at first consideration be considered plenty large for a central preparation plant.

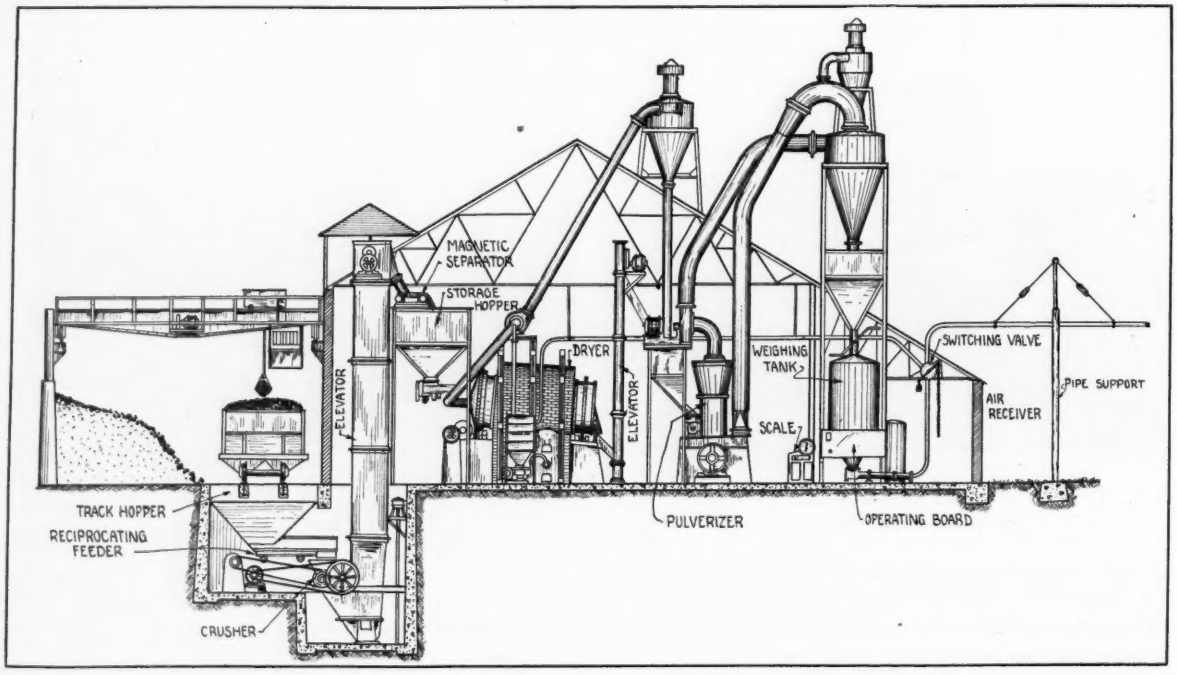


FIG. 3. TYPICAL ARRANGEMENT OF COMPLETE PULVERIZED COAL SYSTEM

An analysis of local conditions may show that the coal receiving equipment, conveying system, coal bunkers are all in place and could not be used with a central plant but would work in well with a unit pulverizer by placing the pulverizer in front of boiler and taking coal from the existing bunker.

For an application of this kind, the unit system of pulverizer, firing equipment and changing over the boilers would cost about $20 to $30 per boiler horsepower at rating.

With a central pulverizing system and pulverized coal conveyed by a pneumatic delivery system, for plants equipped with boilers of a total capacity of 5000 to 10,000 b.hp. at rating, the cost of changing over would be from $18 to $25 per b.hp. at rating. Using the central system on smaller installations than the above, the costs would go up, and would vary from $25 to $40 per b.hp. at rating.

The above costs are obtained from recent installations and from installations now under construction. From the data at present available, these costs may be considered fairly accurate, using present day prices of material and labor. Comparison of costs covering pulverized coal and stoker fired boilers will be referred to later.

In preliminary calculations to determine whether it will pay to adopt pulverized coal, a survey should be made of present operating costs, and the coal supply analyzed closely. If a fairly high-grade bituminous lump coal is being used, with a good proportion of the cost per ton being eaten up by freight, then we can look over the local supply for a lower grade slack or screenings, which will cut down the cost per ton at mine and cost of hauling.

One advantage of firing with pulverized coal is that practically any coal can be burned completely and with a small excess air supply. Another important item of saving is in labor—one man can easily take care of six boilers, and in most cases the labor cost is cut in two or better.

Analysis of Operating Costs

As an example of how the savings can be estimated, a typical analysis for a small industrial plant is given:

This plant has seven 350-hp. Stirling boilers, six operated at one time, stoker fired, 9-hr. day, fairly steady load, boilers operating at about 135 per cent of rating, steam being used for power generation during the day, also process work and heating.

Same load is carried at night for process work and heating during the winter months, the annual coal consumption being around 20,000 T. A cheap coal was being burned on the stokers, being Indiana fifth vein or 1½-in. No. 5 Indiana screenings costing $2.65 per ton at the plant. Frequently coal costing 50c to $1 per ton less than that used on the stokers can be purchased for pulverized coal firing but in this case the cheapest coal obtainable was being used on the stokers.

ANALYSIS OF FURNACE AND BOILER OPERATING COSTS

STOKER FIRED

Cost per day of 24 hr.

Labor (Day Shift)—
- 2 Firemen, 12 hr. @60c equals $14.40
- 2 Laborers, 12 hr. @40c equals 9.60

Labor (Night Shift)—
- 1 Fireman, 12 hr. @60c equals 7.20

Total cost per 24-hr. day $31.20

Total cost per day $31.20

Power—

Stokers @ 3.5 hp. per ton burned 70 T. per day of 24 hr.

$\frac{70 \times 3.5}{1.341}$ equals 183 kw.-hr. @ 2c per kw.-hr. equals 3.66

Forced Draft @ 17.0 hp. per ton burned

$\frac{70 \times 17}{1.341}$ equals 900 kw.-hr. @ 2c 18.00

Maintenance Cost—
- Stokers, 70 T. × 5c per ton 3.50

Coal Consumption—

Average burned through year taken as 70 T. per day of 24 hr.

70 × $2.65 per ton equals 185.50

Burned as follows:
- 50 T. for Power Generation $132.50
- 20 T. process work heating and banking fires 53.00

$241.86

PULVERIZED COAL FIRED

Labor (Day Shift)—
- 1 Fireman, 12 hr. @ 60c equals ..... $ 7.20
- 1 Laborer, 6 hr. @ 40c equals 2.40

Labor (Night Shift)—
- 1 Fireman, 12 hr. @ 60c equals 7.20

Total cost per 24-hr. day $16.80

Power—

Unit Pulverizer 25 hp. per ton pulverized

$\frac{52 \times 25}{1.341}$ equals 970 kw.-hr. @ 2c $19.40

Aux. Blower—

$\frac{52 \times 5}{1.341}$ equals 261 kw.-hr. @ 2c 1.94

Maintenance Cost—
- Unit Pulverized 52 × 10c 5.20

Coal Consumption—

Average consumption per day of 24 hr. will be 52 T.

52 × $2.65 ..... 137.80

Burned as follows:
- 40 T. for Power Generation $106.00
- 12 T. process work heating and banking fires 31.80

$181.14

In addition to the above, when comparing pulverized coal with stoker firing, savings may be made as follows:

No shut-down for cleaning grates.
No loss of coal while cleaning grates.
Less ash removal.
No mechanism inside combustion chamber.
Accurate control of air and coal.
Increased flexibility of operation.
Ability to burn coal of lower B.t.u. content.
Increased efficiency of boiler.

This analysis shows a saving of $60.72 per day, and assuming 280 working days a year, we obtain an annual coal and labor saving of $17,001.60. The total cost of pulverized coal equipment based on present day prices, together with the cost of changing over the boilers would be approximately $42,000.00.

Where a cheaper coal can be obtained and pulverized, and the cost per ton is lower than the hand fired or stoker coal, the savings will be greater and the change to pulverized coal will be a more attractive and profitable investment. The coal saving shown may be considered by some engineers to be high; however, the boiler efficiency with the stokers is 60 per cent during the day load, and on boilers of this capacity fired with pulverized coal, efficiencies of 80 per cent or better have been obtained.

A check of the coal consumption at 60 per cent and 78 per cent show a saving in coal of about 23 per cent, so that a 20 per cent saving can reasonably be expected with careful operation.

At 60 per cent efficiency the coal consumption is:

$34.5 \times 970.4 \div (12{,}500 \times 0.60) = 4.46$ lb. of coal burned per b.hp.

At 78 per cent efficiency the coal consumption is:

$34.5 \times 970.4 \div (12{,}500 \times 0.78) = 3.43$ lb. of coal burned per b.hp.

Maintenance of Piping Systems

Familiarity with Piping Layout Is of First Importance When Taking Charge of a Plant. By A. K. Vradenburgh

TO GIVE a definite plan for power plant piping inspection which will cover all plants is not within the scope of this article. Some concrete examples, however, gleaned from the writer's experience, I trust, will help others not so long in the business to master difficulties which otherwise may be troublesome.

Blue prints of the entire piping system should be accessible to all employes who are in any way responsible for the operating and repairs and each one should be required to familiarize himself with the entire layout so that quick action can be taken in case of an emergency.

Whenever a new man is brought into the service, the chief engineer or his assistant should take sufficient time to go over the entire plant with him so that he may get a fair idea of the layout, then a study of the above-mentioned blue prints will be much more quickly digested.

If the recommendations given in the two preceding paragraphs are not followed out and after the new man has been in your employ a week or two, a pipe bursts, gasket blows, or a reducing pressure valve diaphragm ruptures and he is not able to locate and close quickly the valve or valves necessary to cut out the break and considerable damage is done, blame yourself and not the engineer.

This may seem like a useless suggestion. I know, however, of more than one power plant where the engineer is dumped into his new place, so to speak, and virtually told there it is, make the best of it, and he is given plenty of misinformation instead of information which he should have. This is not done by the chief engineer but by one of the assistants who has never worked in any other plant and knows but little about the one in which he works.

No blanks, charts, or anything of the kind to be filled in by the one making piping inspections are employed in my plant for this is one thing I usually do myself, accompanied by the pipe fitter who will make any needed repairs or changes.

When taking charge of a strange plant, a general survey of the entire layout is taken as soon as possible.

Pipe Drainage Receives First Attention

Unless there are repairs or changes to be made which require immediate attention, my first consideration is drainage of all steam lines both high and low pressure, especially the latter, for usually the former are found to be quite well taken care of, but the latter, especially in heating systems and where the exhaust is used for heating or other domestic purposes, have in many cases been badly neglected.

In one power plant which came under my notice there were three return tubular boilers which were leaking badly at the rear tube ends and portion of the girth seams and rivets were leaking too. An internal inspection showed quantities of oil in each boiler brought there from the heating system in which all of the exhaust from the engines and pumps was used, and on investigation, there were found on the exhaust line two oil eliminators with all drain connections plugged and it took a pipe fitter and two helpers two days to get the drain openings clear and connected to a trap. Later, I learned that this condition had existed for about 6 yr. The wonder is that the boilers were not ruined.

In another power plant which was brought to my attention, two engines were installed at first and later the third and much larger engine was connected to the same exhaust line as the others. Everything went well for a time until one day the cylinder head of the new engine knocked out.

After repairing the damage, it ran for a few days when the cylinder head again departed from its usual place and the crosshead was broken at the same time. The chief engineer wanted to blame the engine for the trouble so the engine builders had a disinterested mechanic, one who was acceptable to the chief engineer, to investigate conditions and this is what he found. The end of the exhaust line where the drain was located was 6 in. higher than the end where the large engine was connected, and at that point an expansion trap was installed which was entirely too small to take care of the condensate even if it had been working but it was prevented from so doing by a closed valve between it and the low end of the exhaust line and due either to the pump action of the piston of the large engine or from the pressure exerted on the body of water by the exhaust from one of the other two engines which were running at the time of the break, the water was forced into the cylinder of the large engine, resulting in the damage previously mentioned. A properly trapped drain located at the low point prevented any further damage from an accumulation of water in the exhaust line.

Spare Trap Helps Maintenance

Usually there are quite a number of traps, both high and low pressure, in power and heating plants and these should be given careful inspection at the first opportunity, for quite frequently most of them will be found to leak, that is, permit steam blowing through the valve and this is a source of much waste fuel. If possible, have a spare trap on hand like each kind in use, especially if there are several of one make and size, then there will be no difficulty in removing one trap at a time and giving it a thorough cleaning and repairing, which will usually be found necessary in a plant which has been in use several years. The cost of a few extra traps will be small in comparison to the saving which can be made by keeping tight trap valves.

Provisions for Expansion

In most of the plants recently constructed, provisions for expansion have been carefully looked after, while in many older plants, little attention has been paid to this point in piping and the layout as found will need to be studied to ascertain just what changes may be necessary to obtain the desired results. The expansion bend is the proper appliance to use if space for its installation will permit, and, in fact, is the only expansion provision that should be made where higher pressure, superheated steam is used. The expansion joint of the sliding type is permissible and serves a good purpose in low pressure steam lines and return lines.

If it is necessary to use the expansion joint in lines carrying a steam pressure of 80 to 125 lb. do not pack

them with square flax and expect them to remain tight any length of time.

Here is another point which it hardly seems that one would fail to get right, yet I have come in contact with several "hook-ups" in which this thing was wrong; that is, when piping up the steam line to turbo forced draft blowers a strainer is used, or should be, in the steam line near the turbine, the stop valve connected between the strainer and the steam supply. This is to prevent any foreign substance getting into and clogging up the small openings in the turbine steam nozzles.

While the above is the right connection, I have seen the valve and strainer reversed and in one instance pieces of the discs had lodged in the steam nozzle openings, thereby reducing the speed of the blower to such an extent that the draft was materially reduced, and the writer was called to investigate the trouble and provide a remedy.

Choose some color scheme for your piping, especially if rather complicated, and paint the covering accordingly; at points where confusion may occur, in case quick action is required, paint an arrow on the visible side of the line, or on both sides as conditions may indicate, pointing in the direction of the flow of the contents.

Tag all important valves and indicate thereon what part of the plant or particular machine each one controls.

If possible, all large valves should be operated at least once each week to be sure they are in thorough working order.

Valve stem packing should be kept in as good condition as that on the main engine piston rod and valve rods.

When the valve stem leaks, tighten the stuffing box nut until the escaping steam is stopped provided it can be done without exerting too much strength on the wrench, otherwise put in new packing. Do not tighten until the thread is stripped or the nut split.

Making Pipe Joints

To insure tight pipe joints take particular care in threading also in making up.

All pipe stocks have marks indicating the set of the dies for correct depth of thread for the size of pipe noted on the die or the face plate of the stock. These marks are intended to be used with the standard thickness of pipe but I find much more satisfactory threading can be done, even though a little more time is required, by taking two cuts instead of making the full depth of thread the first time over.

Should the work be such that extra heavy pipe is required, more than two cuts will, frequently, be required to make a satisfactory thread.

If care is taken in threading pipe and the accompanying table is followed, there will not be much trouble experienced with leaking joints.

This table is given up to 10 in. but whenever possible I would recommend Van Stone or some similar joint for all pipe above 4 in. on steam pressure above 75 lb. and even on 4-in. pipe this type of joint should be employed where high steam pressure and superheat is used.

When pipe threads are cut properly and the joint made up right, there will be no need of any "dope" to produce a tight connection; it is good practice, however, to use some graphite compound on the thread for this will enable screwing to be done more easily and whenever it may be necessary to dismantle, the joints can be broken readily without much trouble.

On flanged joints, my practice is to use ring gaskets wherever possible and "dope" them with graphite. The two will aid materially in breaking a joint when required to do so and many times the gasket can be used again.

Of course I appreciate the fact that many pipe fitters and engineers object to the ring gasket, as they claim the flange is likely to be cracked while screwing up the bolts. This may easily be done, especially if the gasket is thicker than $\frac{1}{16}$ in. and care is not exercised in screwing up evenly on the nuts: a good mechanic, however, will take proper precautions in making up the joint and will use the ring gasket if possible.

Where leaks occur in thread joints especially at flanges and the time for making repairs is limited, the pipe joint clamp, of which there are several reliable makes, if properly applied will, unless the leak is too large, produce a repair job, which will last as long as the rest of the pipe and at much less expense than to renew the pipe.

DISTANCE FITTINGS SHOULD BE SCREWED ON TO THE PIPE BY HAND AND FINISHING WITH A WRENCH

Pipe size, Inches	By hand, Turns	With Wrench, Turns
1	4½	3½
2	4¾	4
3	5	4½
4	6	4½
5	6¼	5
6	7	5
7	8	5
8	8½	5
9 and 10	9	5

Take special care to have all pipe adequately supported and thoroughly covered.

After the piping and its accessories, that is, traps, expansion provisions, hangers, covering, anchorage, etc., have been placed in first class condition, inspections of about once each month should keep everything in good condition, provided a constant and uniform steam pressure is maintained at all times.

Frequently turning on and off of steam from a long line of pipe or wide fluctuation of pressure will start leaks and deterioration more quickly than any other method of procedure that can be followed in steam plant work.

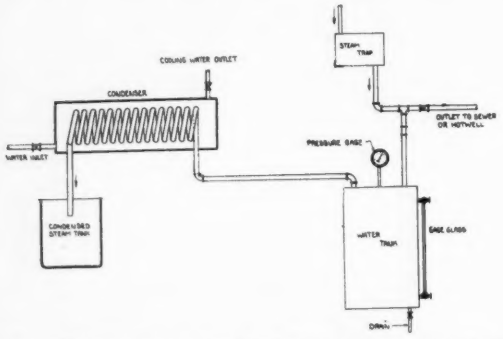
One common source of air pockets in a suction line lying horizontally or sloping upward toward the source of supply, is the ordinary taper reducing fitting. In nearly all cases, fittings can be obtained of the so-called eccentric type which are made for the particular purpose of avoiding air pockets. Another important point in connection with suction lines is to make sure that the end of the suction pipe is submerged to a sufficient depth to prevent the pump drawing in air. If a suction line ends a short distance beneath the surface of the water, the velocity of the water entering the suction line will create swirls or small whirlpools which carry air into the pump. The amount the suction line must be submerged is dependent both on the size of the line and the velocity of the entering water. It is never safe to have less than 3 ft. of water over the end of the pipe for small suction lines and for large ones not less than 6 ft.

Traps Should Be Tested for Heat Loss

Weight of Water Passing Through Trap and Steam Used May Be Easily Determined. By George E. Gaster

PROBABLY no other power plant equipment is so often neglected as the steam trap. This statement is especially true of large industrial plants such as steel mills, paper mills and oil refineries.

When a steam engine, steam turbine, or other piece of similar power plant equipment, ceases to function properly, the fact can easily be detected but a steam trap may be leaking steam, part or all of the time, or the trap may permit neither steam nor water to pass through. Yet these facts can only, in many instances, be ascertained by a careful inspection by a competent individual.



ARRANGEMENT OF APPARATUS USED IN MAKING A TRAP TEST

Several years ago, the writer was called upon to make a report on the condition of the steam traps in a large steel mill. These traps were supposed to have been inspected daily by a pipe fitter. The traps were all found to be comparatively clean and no traps were "plugged up" but 44 per cent of the traps were found to be leaking steam.

Much trouble is sometimes experienced with trap inspectors and maintenance men passing by steam traps without carefully inspecting them. One system designed to insure more careful inspection of steam traps, was installed in one plant under the surveillance of the writer. This system worked out successfully.

Every steam trap in the plant was given a number. The number was painted on a metal tag attached to the trap. Once a day, the inspector had to report on the condition of each trap by number.

Correct Type of Trap Should Be Applied

There are many different types of steam traps on the market but it is impossible to say that certain types are good and other types are bad. One of the best steam traps on the market for use with saturated steam is not very satisfactory for superheated steam. In other words, it is all a problem of picking the steam trap best adapted for the conditions under which it will have to operate, taking into consideration, first cost, depreciation, maintenance, reliability, adaptability to installation, and whether the trap will remove all of the condensate with a minimum amount of heat loss under actual operating conditions. Although a rough estimate of the heat loss may be determined by inspection, it can be accurately determined only by carefully conducted tests.

Many plants in the country are equipped with several different makes and types of steam traps. From time to time these plants are installing additional traps. It is the writer's opinion that it is a profitable investment to make a comparative test on these different types of steam traps under their own actual operating conditions. The information thus acquired will not only be of value in selecting traps for future installations but it may also be used in securing better results with the traps already installed.

To conduct a test to determine the steam loss through a steam trap requires only one or two men. The equipment necessary consists of a tank to catch the water, a condenser to condense the steam, and a vessel to receive the condensed steam, together with the necessary piping and means to measure or weigh the water and condensed steam.

Figure 1 shows one method of arranging the apparatus for conducting a test. At the beginning of the test, the outlet to the sewer should be closed and the valve leading into the water tank should be opened. The water and steam that pass through the trap will flow into the tank. The water will remain here, while the steam will pass out to the condenser, where it will be condensed and flow as water out into the condensed steam tank.

RESULTS OBTAINED IN TESTING TWO STEAM TRAPS

	Trap No. 1	Trap No. 2
Duration of test. Hours	8	8
Lb. of water. Water Tank	1160	1092
Lb. of condensed steam	217	2784
"Heat of the liquid" at 150 lb. gage B.t.u.	338	338
"Heat of the liquid" at zero lb. gage B.t.u.	180	180
B.t.u. given up by each lb. of water due to reducing pressure	158	158
Lb. of water evaporated by the "heat of the liquid" given up	225	212
Lb. of water actually passed through trap.	1377	1304
Lb. of steam lost through trap	0	2572
Lb. of steam lost through trap per hour	0	321.5

It is thus possible to measure or weigh the water as it is drawn from the water tank or the amount can be estimated by measuring the change in the water level in the gage glass. The condensed steam in the condensed steam tank can be measured or weighed as found most convenient.

If the pipe leading from the water tank is sufficiently large, there will be nearly atmospheric pressure in the tank. It is well, however, to have a pressure gage on the water tank to eliminate any possible chance of an error.

It might be well to state here that, as the water in the steam trap under high pressure passes out into the water tank where it is subjected to a lower pressure, a part of the "heat of the liquid" will be available for evaporating water in the water tank. The steam thus formed will pass over through the condenser along with the steam that leaks through the trap. This accounts for the fact that the discharge from all steam traps contains some steam.

Around many plants there are containers for holding lubricating oils, which will answer the purpose of a water tank. A discarded oil cooler from a steam turbine, or a water cooler similar to those used on drinking fountains, will answer the purpose of a condenser. In case a condenser is not available, a barrel part full of water may be used and the steam pipe allowed to extend down into the water. The amount of water in the barrel at the end of the test minus the amount of water in the barrel at the start of the test equals the amount of steam condensed. If accuracy is desired, it is imperative that all steam be condensed and none allowed to escape.

In the accompanying table is given the results of a test on two different types of steam traps. These traps were of the same size and had been in service for a period of one year, under the same operating conditions. Radiation was neglected in determining the results of this test.

Method of Computing Results

Some of the results shown in the accompanying tabulation require calculations, although these are quite simple. It is necessary, for instance, to figure the amount of steam which will be generated in the water tank, due to the heat of the liquid and then subtract this from the total steam condensed in the condenser. The resulting figure will be the steam discharged by the trap.

For the test on trap 2 the calculations are as follows: Heat of the liquid at 150 lb. gage, 338 B.t.u. Heat of the liquid at zero lb. gage, 180 B.t.u. The heat given up by each pound of water, when pressure is reduced from 150 lb. to 0 lb. is 338 — 180 or 158 B.t.u.

As the latent heat of evaporation at 0 lb. gage is 970.4 B.t.u., $970.4 \div 158 = 6.14$, or out of every 6.14 lb. of water discharged, 1 lb. will be evaporated into steam. Or assuming that no steam leaks through the trap, for every 5.14 lb. of water that accumulates in the water tank during a test, you will get 1 lb. of condensed steam in the condensed steam tank.

Pounds of water accumulated in water tank during test is 1092. Pounds of steam evaporated from water discharged from trap $1092 \div 5.14 = 212$. As there are 2784 lb. of steam in condensed steam tank, the steam which leaked through trap during test is $2784 - 212 = 2572$ lb.

In the results of the test on trap No. 1, it will be noticed that there were only 217 lb. of condensed steam, but that theoretically 225 lb. of water was evaporated from the water tank, due to the water passing from a high pressure to a lower pressure. This discrepancy is probably due to the fact that some heat is lost by radiation, and therefore not available for evaporating water.

Generating Steam from Waste Heat

Waste Heat Boilers Must Be Designed to Evaporate Water Almost Wholly From the Heat of Convection. By C. H. S. Tupholme

WITH THE campaign for fuel economy at its height, the attention of power engineers has turned more and more towards the utilization of waste heat from various processes for the generation of steam, with the result now that such a practice is general in many British industries and extraordinarily good results and high efficiencies have been obtained. In the past it has been difficult to impress upon engineers that the problem of the waste-heat boiler is entirely different from the solid fuel-fired boilers and it has been the adaptation of the ordinary solid fuel boiler without substantial alteration to waste-heat recovery conditions that has done much to prejudice engineers against the entire practice.

As several waste-heat recovery experts have repeatedly pointed out, the question of disposition of heating surface in these boilers seems to be little appreciated, yet it is actually the crux of the whole problem. The coal-fired boiler has been designed principally to absorb heat units from high-temperature furnace gas and, in consequence, the boiler and furnace have been proportioned to achieve the best results in combination. High-temperature furnace gas possesses high radiant heating qualities and the solid fuel boiler is designed to make the most of this radiant heat.

With a furnace temperature of 2700 deg. F., as is found in a first-class water-tube boiler equipped with a mechanical stoker, about 66 per cent of the heat absorbed by the plant is due to radiation.

Now consider a similar type of boiler fired by waste heat at 1000 deg. F. According to one authority, the radiation absorption varies as the fourth power of the absolute temperature of the radiating medium. Thus, in the case of this boiler operating on waste heat, the percentage of heat absorbed by radiation is only 3 per cent of its total absorption as a waste-heat boiler. Suppose that, in the water-tube boiler mentioned, the maximum evaporation per square foot of heating surface in a particular section of tube immediately over the fire is 66 lb. from and at 212 deg. F. per sq. ft. per hour, this being due to radiant absorption, then the evaporation in the corresponding section of tube in an exactly similar boiler working on waste heat will be only: $66 \times 3/66$ or 3 lb. per sq. ft. from and at 212 deg. F.

Assuming both boilers to be evaporating 10,000 lb. of steam from and at 212 deg. F. per hr., then the fuel-fired boiler is evaporating 6600 lb. by radiant heat and 3400 lb. by convection, while the waste heat boiler is evaporating 300 lb. by radiant heat and 9700 lb. by convection. Thus, for each boiler to develop its convection output the waste heat unit must have a transfer rate by convection of nearly three times that of the coal boiler.

Again, consider the question of circulation. It will easily be understood that a boiler with a positive and vigorous circulation when dealing with gas from 2500 deg. F. down to 600 deg. F. will often behave differently on gas entering at 900 deg. F. and leaving at 400 deg. F. It is often the case that a good coal boiler, for this reason alone, will be unsuitable when used as a waste-heat boiler.

Design of waste-heat boilers has demanded a special study and has involved problems different from those encountered in evolving direct-fired units. That many of these problems have been solved is shown by the resulting economies effected in power generation by employing for steam-raising purposes the gas which would otherwise have been rejected to atmosphere.

For instance, in the case of a city gas plant using Glover-West vertical retorts, it was found that with an average combustion chamber temperature of 2375 deg. F., the temperature of the waste gas at the base of the shaft averaged 1650 deg. F., with a CO_2 content of 16 per cent. Waste gas of such a temperature obviously was extremely valuable for steam raising. Taking the fuel consumption per generator per setting at 336 lb. per hr., it was calculated that there was sufficient heat passing from each setting to produce over 1930 lb. of steam per hr., if it all could be absorbed. Assuming at the outlet of a boiler a reduction of temperature to 390 deg. F., and allowing for boiler efficiency and heat losses between the base of the shaft and the boiler, it was estimated that at least 1300 lb. of steam at 100 lb. pressure per setting per hour could

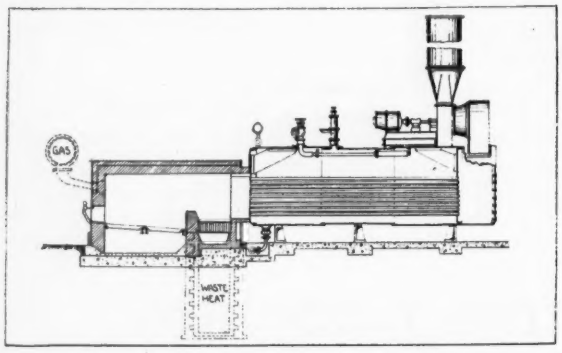


FIG. 1. APPLICATION OF HORIZONTAL TUBULAR TYPE OF BOILER TO WASTE HEAT RECOVERY

be produced. This would amount to 1300 lb. of steam per ton of coal carbonized and to 3.87 lb. of steam per lb. of fuel used in the producer.

Horizontal Tubular Waste Heat Boiler

One waste-heat boiler which is now being used successfully on this class of work is the Kirke, shown in Fig. 1. The essentials of this boiler are: It is a fire-tube unit having its heating surface so correlated with the requisite draft conditions as to give an extremely high heat transference, coupled with a tube efficiency of approximately 90 per cent, the draft drop through the tubes themselves being generally from 1 in. water gage upwards.

Hot products of combustion travel through the tubes in an absolutely straight path and thence change their direction, hence the power required by the fan (seen on the top of the boiler behind the stack) is low. The boiler has adequate cleaning facilities for dealing with dirty gas without interfering with the operation of the plant. As the waste gas leaving the boiler is only a few degrees higher than the steam itself, an economizer is not necessary and is generally eliminated.

In Fig. 1 the Kirke boiler is shown arranged for simultaneous firing or alternative firing with coal, waste heat or gaseous fuel. The superheater, which may be armored if thought desirable, is arranged out of the path of gas that has a high temperature and is heated from the combustion chamber walls by radiation or by contact with waste gas at a low temperature discharged from an industrial furnace, or by both. The tube ends are beaded over and may be armored with ferrules. This illustration also shows how the tubes may be cleaned while the boiler is in operation.

In this boiler the use of a high velocity of flow through the tubes enables a small boiler to be made for a big output and the capital cost to be kept low. The high velocity is compensated for by having the tubes exceedingly long relative to their bore, the length depending on the velocity chosen and the temperature of the hot gas entering the boiler. The tube efficiency is usually around 90 per cent, though it has been as high as 94 per cent.

Results of Tests on Waste Heat Boiler

One test recently carried out on this boiler gave the following results:

Temperature of products entering boiler	932 to 977 deg. F.
Outlet temperature of products leaving boiler	356 to 374 deg. F.
Steam pressure in lb. per sq. in	90
Temperature of steam	320 deg. F.
Temperature of products leaving boiler above that of the steam	57 to 77 deg. F.
Mean tube efficiency of boiler, i. e., difference between temperature of gases entering and leaving tubes divided by difference between temperature of gases entering tubes and that of water in the boiler	94.5%
Suction in the outlet products chamber, in. water	2⅝
Suction in inlet products chamber available for furnace	1⅝
Horsepower of motor for furnace and boiler	20
Water evaporated per hour actual in lb.	6000 — 6300
Water evaporated from and at 212 deg. F. per hour in lb	6400 — 6720
Percentage of power developed absorbed by draft for boiler, assuming 15 lb. steam from and at 212 deg. F. per b.hp.-hr.	1.75%
Percentage of power developed absorbed by draft for furnace, assuming 15 lb. steam from and at 212 deg. F. per b.hp.-hr.	2.85%
Estimated coal saving per annum in tons, assuming 10 lb. of steam from and at 212 deg. F. per lb. of good coal	2500
Coal consumption in tons per hour in producers, approximately	1.25

Other tests give boiler tube efficiencies of 89.6, 90, 90.8, and 86 per cent, or an average of 89.1 per cent.

Another popular type of waste-heat boiler is that shown in Fig. 2, which is the Woodeson. This boiler is made up of one or more sections, each consisting of a steam drum at the top, a water drum at the bottom and a number of groups of tubes, the number of groups in each section depending on the size of boiler used. The whole boiler is suspended on girders and is free at the bottom to allow for expansion.

Manholes Arranged for Tube Removal

Over the top of the steam drums is arranged a series of manholes, one immediately over each group of tubes, and any tube can be withdrawn and replaced through the manhole above the particular group in which the tube is located.

Feed water enters the steam drum at the point farthest away from the fire and flows down the tubes in the rear and up those in front. The advantage claimed for this type of construction is that, as the water enters the boiler at the coldest part and flows down the rear tubes in contact with the coldest gas, it precipitates any mud or dirt into the bottom drum and all the tubes in front which are in contact with the greatest heat have practically clean water to deal with, therefore no deposit is found in any of the tubes exposed to great heat.

Waste gas from the furnaces and supplementary grate, if any, passes immediately in front of the tubes and the gas travels upwards among the tubes and over the fire-

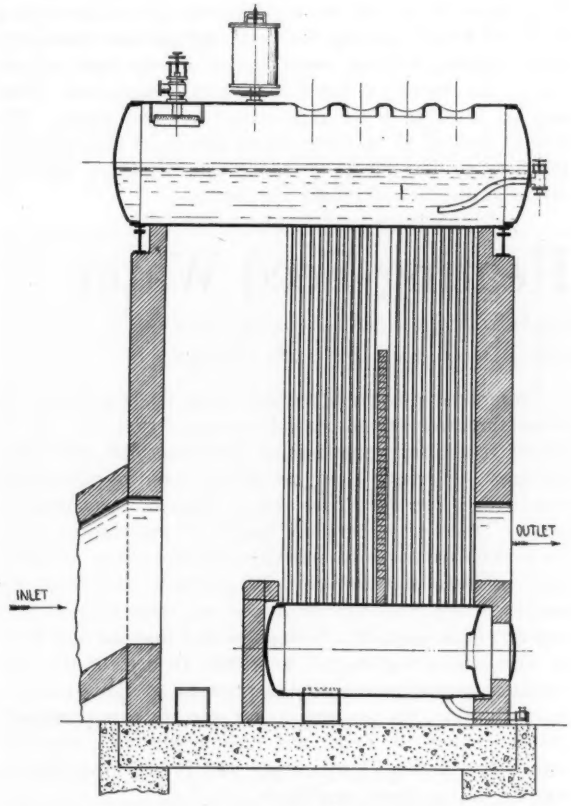


FIG. 2. VERTICAL-TUBE TYPE OF BOILER IS WELL ADAPTED TO WASTE HEAT RECOVERY

brick baffle arranged between the groups and downwards among the tubes and out at the back wall.

These boilers are arranged to deal with gas at about 2000 deg. F., the evaporation ranging between 1120 and 5600 lb. per hr., according to size.

In addition to waste furnace gas, boilers of this type are in use for dealing with the waste heat from the exhausts of internal combustion gases. The discharge temperature of a gas engine operating at full load runs from 840 to 930 deg. F., and the exhaust gas contains some 40 per cent of the total energy supplied to the engine as heat units. The great difficulty here, which has prevented high efficiencies in this type of recovery, is the corrosion problem; until this is solved, waste-heat recovery on gas and other internal combustion engines will remain almost undeveloped.

Calculating Steam Flow for Turbines*

METHOD BY WHICH STEAM CONSUMPTION OF A TURBINE MAY BE CALCULATED. BY J. Y. DAHLSTRAND†

WHEN CALCULATING the size of nozzles for a steam turbine or the steam flow for a given turbine, each stage is treated separately. The nozzle dimensions depend upon such variables as the pressure ahead of the nozzle, the pressure behind the nozzle, the total steam flow through the nozzle, the quality of the steam and the nozzle efficiency.

If the steam used by a turbine is superheated the specific volume of the steam will change with the degree of superheat and therefore the specific volume must also be known. For the sake of simplicity, it may be assumed here that nozzles for a single stage turbine are to be cal-

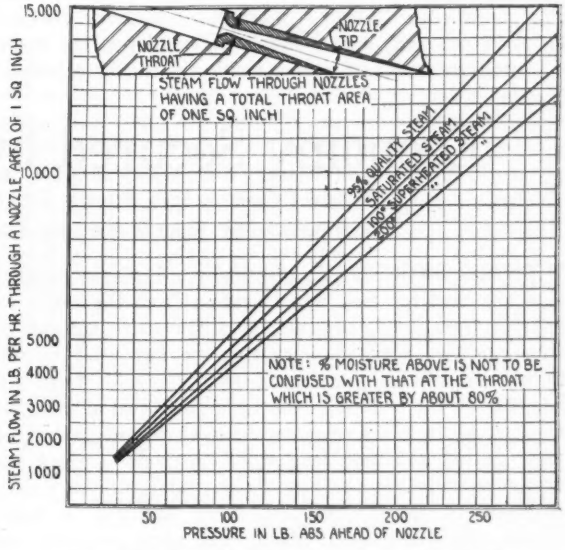


CHART FOR DETERMINING STEAM FLOW THROUGH NOZZLES

culated. Nozzles for multi-stage machines are calculated in the same manner after the pressure drops and steam conditions in each stage have been determined.

Steam flow is a function of the pressure ahead of the first stage nozzles, this pressure being called the ring pressure. This is exactly true for a single stage machine and is true within a small percentage for any turbine, regardless of the stages following the first. If the throat areas of the nozzles in the first stage are measured and the ring pressure of the turbine is observed, then the steam flowing can be calculated with an accuracy which will be within 2 per cent of the actual steam flowing. Accuracy depends, of course, upon the nozzle roundings being good so that a constriction does not take place at the nozzle mouth.

With an understanding of the above factors, and a knowledge of the total steam flow per hour, the number of nozzles which should be used may be calculated. In the fundamental equation $c = \sqrt{2gh}$; c is the velocity, g is the acceleration due to gravity and h is the head in feet or work in foot pounds if the equation is concerned with

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†Chief Engineer, Standard Turbine Co.

1 lb. of weight. If there is a total adiabatic heat drop of A. B.t.u. to be utilized, then, instead of h, we may substitute in the equation, $788 \times A$ ft. lb. and the equation will then read $c = \sqrt{2g \times 788 \times A}$ or $c = 223.7 \sqrt{A}$, since $g = 32.2$ ft. per sec. The velocity thus arrived at is the velocity at the tip of the nozzle.

Velocity at the throat of any nozzle can reach a maximum of only 1476 ft. per sec., which corresponds to a pressure drop through the throat of 58 per cent of the ring pressure. The area at the throat of the nozzle can be calculated from the following equation:

$$A = \frac{S}{60 \times 60} \times \frac{V_t \times 12 \times 12 \times Q}{1476 \times E}$$

in which A equals the area of the throat in square inches; S equals the steam flow through one nozzle in pounds per hour. V_t equals the specific volume in cubic feet per pound at the throat pressure (this being 58 per cent of the ring pressure); E equals the nozzle efficiency (usually about 95 per cent) and Q equals the quality of the steam.

Similarly, the area at the nozzle tip can be calculated by inserting in the above equation instead of V_t the quantity V_2, which is the specific volume in cubic feet per pound at the tip of the nozzle and also in place of the figure 1476, insert the figure arrived at above for the steam velocity (c). The relation between the area of a nozzle at the tip and that at the throat is called the ratio of expansion.

By means of the above method, nozzles can be readily proportioned. In many cases it is valuable to be able to check the flow of steam of a given turbine. This can readily be done as outlined above if the throat areas are measured accurately and the pressure ahead of the nozzle measured by means of a calibrated instrument.

To render more simple the calculation of the steam flow, there is plotted in the diagram given herewith a series of lines showing the total steam flow through a nozzle having a throat cross section of one square inch. One of the lines gives the flow for saturated steam. There also are other lines for superheated and wet steam. The flow as arrived at by these charts should be multiplied by the area of the throat of the given nozzle in order to arrive at the flow through that nozzle.

Economy Secured by Heating Feed Water

RECENT PRACTICE HAS SHOWN THAT IMPROVEMENT IN PLANT ECONOMY CAN BE OBTAINED BY FEED WATER HEATING WITH BLED STEAM. BY C. E. COLBORN

UNTIL RECENTLY, practically all plants obtained the heat for feed water heating from the steam exhausted from house turbines, auxiliary drive turbines or from engines. Feed water heating was first used in order to prevent strains that would result if cold water was admitted to the boilers. Recently a great deal of attention has been given to the economical aspect of feed water heating. It has not been long since the house turbine was first substituted for the less efficient small auxiliary drive turbines, the auxiliaries then being changed to motor drives. At the present time power plant designers are devising means to secure continuity of auxiliary operation without the use of the house generator thus permitting the extraction of steam for feed water heating from the more efficient main turbines.

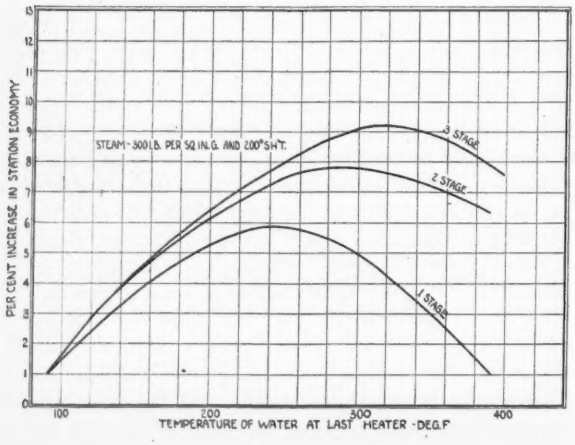


FIG. 1. SAVING RESULTING FROM STAGE FEED WATER HEATING WHEN NO ECONOMIZER IS USED

Several studies have recently been made showing the large improvement in station economy that can be obtained from feed water heating by steam bled from large turbines. Figure 1 shows the saving resulting from heating in one, two and three stages when no economizer is used. These curves are the results of calculations made for a 20,000-kw. turbine unit supplied with steam at 300 lb. gage pressure and 200 deg. F. superheat and when operating at the most economical load and exhausting at 1 in. mercury back pressure. It was assumed that the feed water in each heater was heated to within 10 deg. of the temperature corresponding to the pressure of the steam extracted. Since the per cent saving is in any case practically independent of the boiler and turbine efficiency, these figures shown in Fig. 1 will apply well in any plant having similar initial steam conditions.

Curves in Fig. 1 show that with any number of heaters the saving reaches a maximum at some final temperature which, if exceeded, results in a smaller saving. The temperature at which this saving is a maximum is seen to be higher the greater the number of heaters. In making the calculations in the case of more than one stage heating the bleeding points were chosen that gave the greatest saving with the given final temperatures. These points were found to be such that the total temperature rise in the water was nearly equally divided between the heaters used.

Temperature rise of the water passing through an economizer is practically the same at all operating loads. Assuming that the heat transferred from the flue gas to the water in the economizer is proportional to the logarithmic mean temperature difference and that the flow of water and gas is purely counter-current, the temperature rise of the water will be proportional to the temperature difference between the entering gas and water. This means that any increase in the temperature to which the feed

water is heated by bled or exhaust steam will reduce the temperature rise in the economizer. Because of this variation in heat absorption in the economizers with the feed water temperature it was considered desirable to include the saving in the economizers with that effected by the bleeder heating. The lower curve in Fig. 2 shows the per cent saving effected in the economizer. The upper curves show the total saving resulting from the heating of the feed water in both the bleeder heaters and economizers. It will be noticed that the feed water temperatures that give the maximum economy are in this case somewhat lower than when no economizers are used.

In calculating the saving shown in Fig. 2 the economizer was assumed to be of such size that it would give a temperature rise of 105 deg. F. with 600 deg. F. inlet gas temperature and 200 deg. F. inlet water temperature. The inlet gas temperature in all cases was assumed to be 700 deg. F.

In modern power plants there is no excess of exhaust steam and to increase the feed water temperature requires either the generation of increased amounts of power in

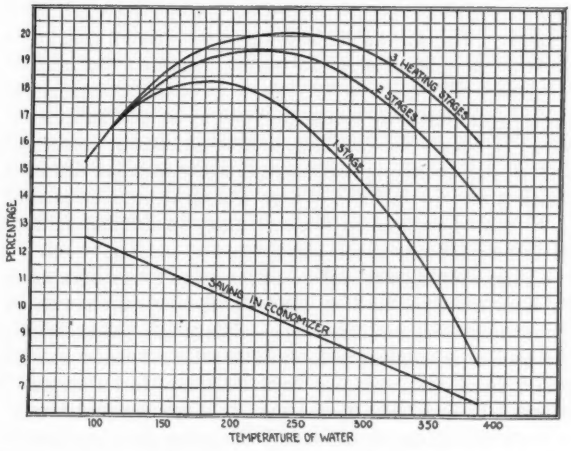


FIG. 2. SAVING RESULTING FROM HEATING FEED WATER WITH EXHAUST OR BLED STEAM USING ECONOMIZERS

non-condensing turbines, with high water rates, or the bleeding of steam which has only accomplished a part of its work in the main turbine. In either case it is necessary to charge against the saving due to the heat added to the feed water the loss resulting from the generation of increased amounts of power at low efficiencies. This gives the net saving resulting from feed water heating which is somewhat lower than the values sometimes given, in the obtaining of which it is assumed that exhaust steam has no value.

Figure 3 gives the relative cost of heat in the form of exhaust steam to that of heat in the form of live steam. To find this value it is required to know the water rate of the main turbine and of the house or other turbines from which the exhaust steam is obtained for heating. If the exhaust steam is obtained from several small turbines the average water rate of these turbines should be taken. If the water rate of the small turbine is given in pounds per horsepower-hour, it should be converted into pounds per kilowatt-hour by dividing by 0.746.

As far as the station economy is concerned the effect of heating the feed water with live steam taken from the

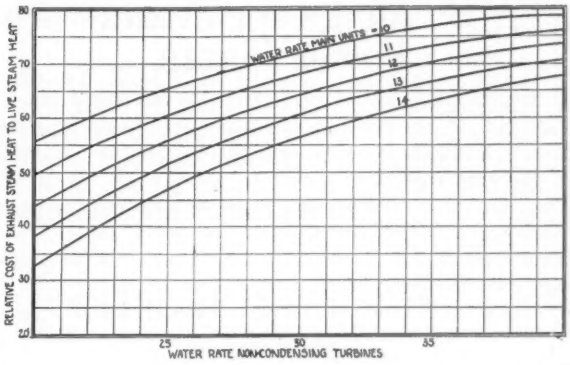


FIG. 3. RELATIVE COST OF EXHAUST STEAM HEATING TO LIVE STEAM HEATING

boiler would be equivalent to not heating it at all. The saving due to heating with exhaust steam is

$$S = (1\text{-}R)H$$

in which S is the saving in B.t.u. per lb. of water heated, R is the relative cost of exhaust steam heating as compared with live steam heating as given in Fig. 3 and H is the B.t.u. added to each pound of steam in the heater.

Knowing the value of R as given in Fig. 3 it is possible to calculate the amount the station economy is increased due to the feed water heating as follows:
per cent increase in station economy equals

$$100\left(1-\frac{H_t-t_c+32}{H_t-t_f+32+R(t_f-t_c)}\right)$$

Where economizers are used the incoming feed water temperature due to heating by exhaust steam reduces the absorption of heat in the economizer. It is well in this case to consider the economizer as an additional feed water heater rather than as part of the boiler. The saving resulting from feed water heating in both the economizer and heater will be

$$\%=100\left(1-\frac{H_t-t_e+32}{H_t-t_e+32+R(t_e-t_c)-(t_f-t_e)}\right)$$

In which H_t is the initial heat content of steam to the turbines; t_c the temperature of the condensate of main unit condensate, or feed water before any heating is done; t_f the temperature of the feed water to the boiler; t_e the temperature of the inlet water to the economizer and R taken from Fig. 3 as before.

AIR RECEIVERS, or tanks, should be placed as close to the compressor as possible so the discharge pipe may be kept short. Never place a stop-valve between safety-valve and compressor. If for any reason a valve must be placed in the discharge line be sure to see that a safety-valve is placed on the line between it and the compressor. If the compressor stands near the wall it is a good plan to place the receiver outside the building where it has an opportunity to radiate some of the heat.

Buildings for Steam Power Plants

LOCATION AND construction of power plant buildings must be based on the economics of each separate installation. The selection of a site involves first a study of the load conditions and then the price of property. The advantages and disadvantages of any location may become involved due to questions of water supply, fuel transportation, ash disposal or a sub-soil suitable for building and machinery foundations. The personnel of a modern plant is not large, therefore the location of a plant is not strictly determined by labor supply as is the case with a factory. Modern methods of transportation have largely taken care of this problem. To be consistent with good planning and management, this labor problem should be considered.

It is more or less universal in power plant practice to separate the boiler room from the turbine room, the obvious reason for this being that the turbine room will then not be subjected to the dust arising from the handling of coal and ash. Further, its operation will not be so readily interfered with due to interruptions in the boiler room. The specific arrangement of the generating units and the boilers is one of individual study, the considerations being the conservation in building size, ease of operation and a simplification of the piping layout. For the small plant, the back to back arrangement is no doubt most economical. This scheme results in placing the boilers all in a straight line, thus giving an outside wall on one side of the firing aisle and so affording an opportunity to take full advantage of day light which is desirable under all conditions.

No great amount of building planning can be done until a complete survey and understanding has been reached as to what equipment will be used. The source of condensing water and the most economical way in which it can be gotten to the condensers is of great importance. Ample space must be provided in the boiler room for pulling and replacing tubes. This also applies to the space opposite surface condenser heads and economizers.

Provide Basements of Good Height

One mistake which is often made is that of considering the basement, particularly under the boiler room, as of secondary importance. They are often constructed with low headroom, insufficient drainage and without windows to the outside. In fact, plants are often constructed with only a tunnel for the ash man to work in. This is cheap construction and does not provide conditions which will promote the good will and good health of those who must work there. Methods of positive ventilation, which come as after thoughts, are usually costly and in most cases do not prove to be entirely satisfactory. In an effort to conserve space, the mistake is often made of making aisles between the boilers and back of boilers so that they cannot be used effectively when maintenance work is going on. A 6-ft. minimum aisle can well be established; this space will allow the passage of trucks or wheel barrows. The space back of the boilers is sometimes established by the size and type of economizer used.

Of first importance when considering the construction of a power station, is a study of the foundation requirements. It may be necessary to make a number of drillings on the site in order to determine the depth it will be necessary to go in order to obtain a suitable bearing. Generally the safest and most satisfactory thing to do is to go down to solid rock. Where this cannot be done economically an allowance for loadings may be made and gravel or other firm bed to be taken advantage of on which to start the foundation. Many cases exist where it is necessary to drive piling in order to get a firm footing.

Safe Loads on Bearing Soils

Loads on foundation soils should not ordinarily exceed the following in tons per square foot:

Ordinary clay	2
Clay mixed with dry sand	2
Dry sand and dry clay	3
Hard clay and firm coarse sand	4
Firm coarse sand and gravel	5
Shale rock	8
Hard rock	20

For all soils which are inferior to the above a load not in excess of 1 T. per sq. ft. should be allowed.

Maximum load to be carried on a pile should not exceed 40,000 lb. or 600 lb. per sq. in. of its average cross section. The allowable load on piles driven by a drop hammer may be determined by the formula:

$P = 2\ Wh \div (S + 1)$, where P equals the safe load on pile in tons; W equals the weight of the hammer in tons; H equals the free fall of the hammer in feet and S equals the average penetration for the last six blows of the hammer in inches. Where a steam hammer is used, 1/10 should be used in place of unity in the denominator of the equation as given above.

Piles should have a penetration of not less than 10 ft. in hard material such as gravel and not less than 15 ft. in loam or soft material. To prepare the piling to take its load it is customary to cut the piles off below the low water level and excavate between them for a depth of about 1 ft. and then pour a mat of concrete around them. This mat is often re-inforced by putting in one course of reinforcing bars a few inches above the pile tops and probably another course at right angles to the first at some point near the top of the mat or slab.

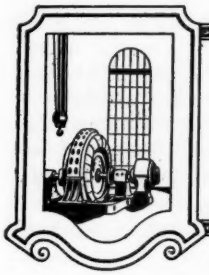
Materials Suitable for Foundations

Materials which may be used in foundation construction are brick, stone and concrete. It has become almost universal practice to use the latter because of its ease in construction, its permanency and its low cost. The working stresses which are allowable for these materials are as follows:

	Lb. per sq. in.
Common brick, Portland cement mortar	168
Hard burned brick, Portland cement mortar	210
Rubble Masonry, Portland cement mortar	140
Portland cement concrete, 1-3-5	280
Portland cement concrete, 1-2-4	420

The pressure of column bases, beams, etc., on masonry should not exceed the following values:

	Lb. per sq. in.
Brick work with Portland cement mortar	250
Rubble masonry with Portland cement mortar	250
Portland cement concrete, 1-2-4	500



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Interconnection of Electrical Systems

A Scheme of Interconnection Which Will Fully Utilize Hydraulic Resources Will Undoubtedly Show Greatest Economy

IT IS GENERALLY conceded that the tremendous development of this country during the latter half of the nineteenth century was due more than anything else to the rapid expansion of our transportation systems. Manufacture and agriculture it is true, also played an important part but it was the railroads that brought manufacture and agriculture together and to the railroads, therefore, is due the largest share of the credit.

Today our civilization is of a more complex nature than it was in the late "eighties" and we are beginning to realize the remarkable influence electricity has upon our lives. Developments in the transmission and distribution of power, and in the field of communication have already multiplied our powers to an extent that even the most imaginative optimist of sixty years ago would not have dared prophesy.

The wealth of a nation today is measured largely in terms of its power resources. Transportation takes care of the supply of raw material and the removal of the finished product but unless a country has power at its disposal it has little chance of gaining industrial supremacy. Power is a basic economic necessity.

The United States, as a nation, is fortunate in having available enormous power resources in all of its various forms, coal, oil and water. It is natural therefore, that these power resources, together with our vast transportation systems and agricultural resources, should make the United States the greatest producing and consuming nation in the world.

In their infancy, prime sources of power, both hydraulic and steam, were utilized directly. The developments were small and the use of power was restricted to the immediate area in which it was generated. Today, due to the advances made in alternating current transmission and to the development of suitable distribution networks power can be transmitted to relatively long distances.

As a result of the larger area it is possible to supply the capacity of our power stations has gradually increased and the necessity for frequent stations of small capacity eliminated.

Now, just as we found the railways necessary as carriers of raw material and manufactured products, so today are we discovering the need of transmission systems as carriers of power. We are beginning to realize the necessity of some sort of national transmission system which would remove any artificial barriers that arise in the path of full and free transmission and distribution of power. Only by means of such a system shall we ever be able to utilize the power resources of the United States in the most economical manner. We are tending towards a condition which has as a limit the supply of power to every man, woman and child in this country from one national power distribution system. Just how close we shall be able to approach this limit depends not only upon future developments in electrical transmission of power but also on a

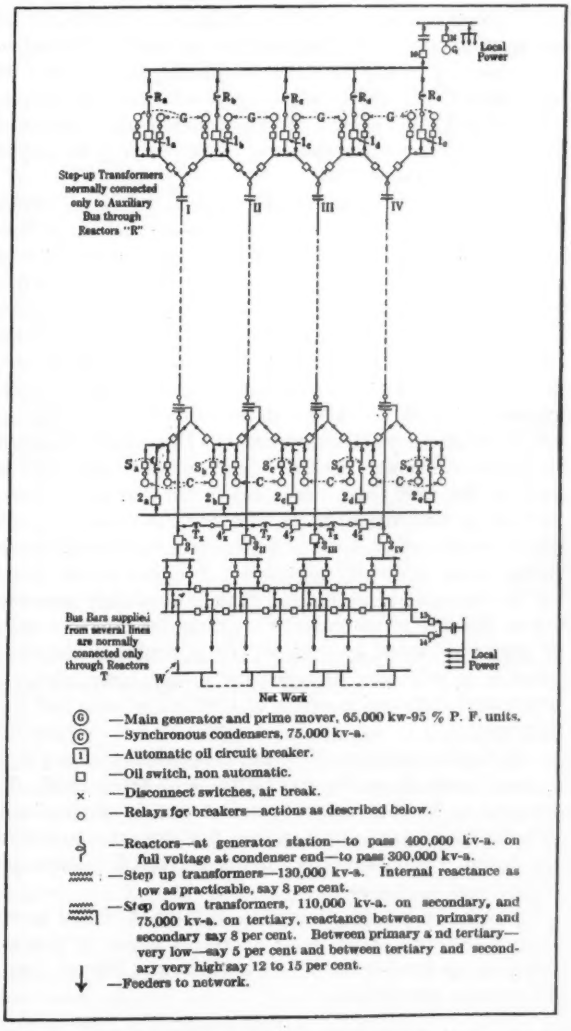

Local Power
Step-up Transformers normally connected only to Auxiliary Bus through Reactors "R"
I
II
III
IV
Bus Bars supplied from several lines are normally connected only through Reactors
Local Power
Net Work
—Main generator and prime mover, 65,000 kw-95 % P. F. units.
—Synchronous condensers, 75,000 kv-a.
—Automatic oil circuit breaker.
—Oil switch, non automatic.
—Disconnect switches, air break.
—Relays for breakers—actions as described below.
—Reactors—at generator station—to pass 400,000 kv-a. on full voltage at condenser end—to pass 300,000 kv-a.
—Step up transformers—130,000 kv-a. Internal reactance as low as practicable, say 8 per cent.
—Step down transformers, 110,000 kv-a. on secondary, and 75,000 kv-a. on tertiary, reactance between primary and secondary say 8 per cent. Between primary and tertiary—very low—say 5 per cent and between tertiary and secondary very high say 12 to 15 per cent.
—Feeders to network.

FIG. 1. A ONE-LINE DIAGRAM OF A TYPICAL 500-MI. SUPER-POWER TRANSMISSION SYSTEM

mutual understanding of the power problem on the part of all individuals concerned.

A superpower system of this type will not be constructed as such. Rather it will be the result of a gradual growth due to combinations of groups of small systems with interconnection between groups. During the past few years many small generating companies in adjacent districts realizing the advantages to be secured from interconnection have merged and today we have several such groups in various parts of the United States.

Adjacent groups have been interconnected and with the full development, the economies of regional or national operation will be realized. A scheme of operation that will utilize the hydraulic resources of the country to the fullest extent will undoubtedly show the greatest economy. This cannot be accomplished by independent operation of different power units as it is impracticable economically to develop a number of projects due to the inability to utilize the power in a way that would justify the expense of development. It must be remembered that each horsepower of hydraulic energy developed means one horsepower conserved while each horsepower of fuel energy developed means one horsepower lost.

Possible Distances of Transmissions in the Future

In considering a national superpower system as here outlined, it must be understood that the greater part of power used in any community will still be generated somewhere nearby. For instance, power used in New York City will be generated by steam and hydro stations in the vicinity of New York and adjoining states. Power used in Chicago will not be transmitted over 2500 mi. of transmission line from the hydro stations on the west coast but will be produced by steam stations in Illinois and Indiana. Hydroelectric power generated on the west coast will be used on the west coast. It is axiomatic that power losses increase in proportion to the distance the power is transmitted, so obviously it would be wasteful to transmit power further than is strictly necessary. In other words, power will be transmitted no further than is absolutely necessary due to distance of the point of consumption from the point of most economical generation. It is doubtful, therefore, whether it will ever be necessary to use large blocks of power over distances in excess of 1000 mi. or even half that distance.

At the present time 1000-mi. transmission of power on a large scale is purely speculative and much work still remains to be done before this feat can be attained with any degree of economy; however, the attainment of 1000-mi. power transmission may not be so far off as some may be inclined to suppose.

While the longest transmission lines in actual service do not transmit large blocks power in excess of 200 mi., calculations have been made which show a 500-mi. line to be entirely practicable.

Operation of a 500-Mile Line

In a paper delivered before the American Institute of Electrical Engineers, in February, 1924, Percy H. Thomas has worked out the characteristics of a 500-mi. superpower transmission line, working at voltages of from 220,000 to 245,000 and delivering regularly 400,000 kw. Such a line will have losses, including line, transformers and condensers, of about 15 per cent, with flexibility such that any unit may be shut down at will without disturbing operation. In this system, a diagram of which is shown in Fig. 1, a short circuit will cause less disturbance than it does on the usual transmission system.

On a basis of power generated at $20 per kw.-yr. on the switchboard and salable at the receiving step-down bus bars in quantity at $50 per kw.-yr. an expenditure of something between $75,000,000 and $90,000,000 would seem to be justified, assuming 12 per cent to be sufficient to cover all fixed charges, or $75,000 to $80,000 a mile for a double circuit tower line including cost of condensers and auxiliaries.

High Tension Distribution Networks

To show further what may be done along lines of superpower transmission and interconnection, Mr. Thomas in another paper delivered before the American Institute of Electrical Engineers at the spring convention, outlined a new type of high-tension network. The central idea of this paper is the superposition of a high tension network of single circuit lines over a large area for the purpose of supplying a medium in which current may flow in any general direction. This is similar to the underground network of the Edison companies in large cities. The network is connected directly to load centers as well as the existing generating centers and thus greatly assists the present distribution lines distributing power and also stabilizes the potential at each load center reached. If such a network is designed favorably, the charging current may largely neutralize the lagging component of the load.

In his paper Mr. Thomas worked out a concrete example of such a network covering the present load with an equal amount of new future load in the interconnected systems of Alabama, the Carolinas, Georgia and Tennessee, with a branch to the Appalachian Power Company in Virginia. The result shows a very effective, efficient and low cost system for this territory.

With such a network, all the advantages of diversity as applying to any interconnection are obtained and while Mr. Thomas does not discuss this question in a numerical sense, he points out that with a 10 per cent gain in diversity on the total peak output of 1,250,000 kw. on the 100-kv. lines, the additional power that might be sold would be 125,000 kw. with no additions to the general installation.

The fact that power generated at any point may be used at any other, without material loss and within any reasonable limit, with the advantage of unitary control for the whole system, would permit power to be sold considerably nearer the total water power available than with the component systems all operating separately.

Perhaps the most important advantage of this network is the opportunity to develop the most favorable power station projects to the exclusion of less favorable ones, which may happen to be nearer the load. If it be assumed that large favorable sites may be developed for $30 a horsepower less than local ones, this would mean for one-half of the 1,000,000 new horsepower considered in this plan, a saving of $15,000,000. This advantage may amount to a much larger sum.

While this network is purely hypothetical, it is based only upon known facts. The plan is applicable to any other district as well as to the district assumed in the problem and it requires no great stretch of imagination to assume that a group of such districts could be again interconnected.

It must not be supposed, however, that the transmission of electric power over long distances is without its

problems. As a matter of fact with the distances now considered practicable the engineer is confronted with a wide variety of problems, some of which are purely economic, while others will be confused more strictly within the limits of the art. Even those purely technical problems are of radically different kinds; for instance, the necessity of the use of higher voltages results in questions of insulation and corona protection, the design of switching equipment, transformers, etc. There is also the problem of determining the limitations upon the amount of power delivered, due to circuits of high relative impedance. This latter question has been thoroughly discussed in a number of papers presented before the American Institute of Electrical Engineers and methods of calculation have been developed for its solution.

tube has been suggested and it is possible that the operation of the future long transmission line will be intimately associated with vacuum tube apparatus.

The "Transverter" developed in England and described in the July 1 number of Power Plant Engineering is of special interest in this connection and engineers are awaiting the installation of apparatus of this kind on a commercial scale to see whether it bears out the great promise that it makes in the experimental stage. This apparatus as installed at the British Empire Exposition at Wembley converted direct current at 100,000 v. to alternating current at 3000 v. It may however, be designed for transformation in any direction.

In Europe, the Thury system of direct current transmission has been used for a number of years and has given

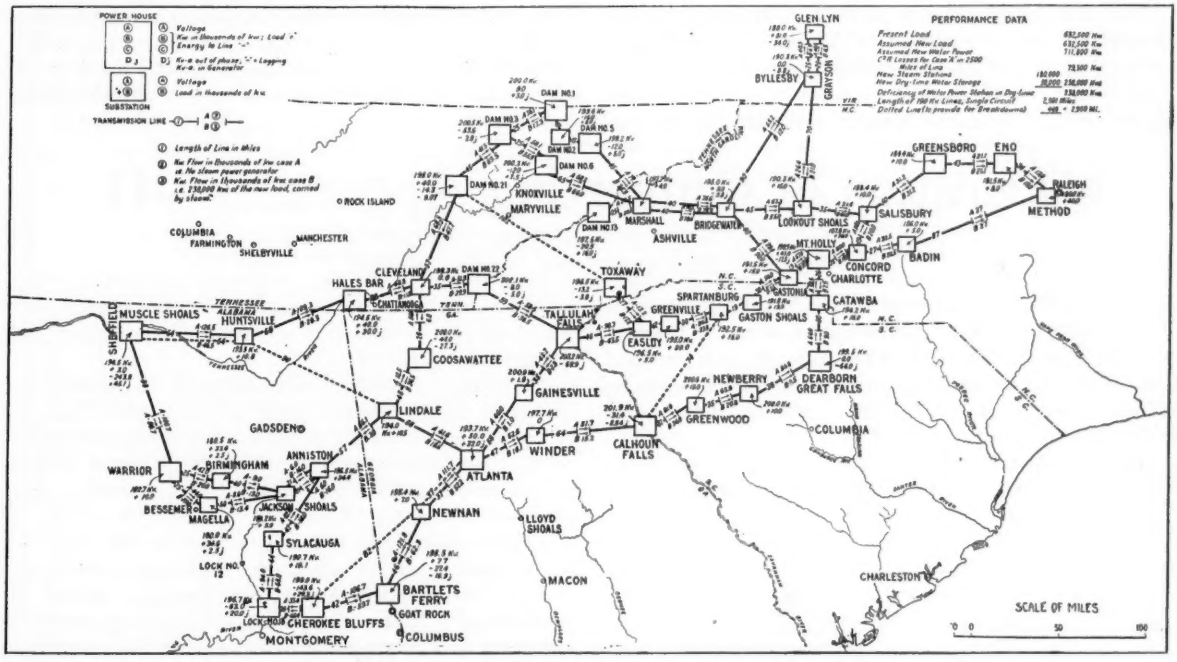


FIG. 2. PROPOSED HIGH TENSION NETWORK FOR SOUTHERN POWER SYSTEMS

In any consideration of interconnection involving long distance transmission of electric energy, the question of providing synchronous apparatus for securing stability is an important one and one that often proves costly. This brings up the question of direct current transmission, which would entirely eliminate inductive and capacity effects and do away with the necessity of providing automatic synchronous apparatus. This question was briefly touched upon by Prof. Miles Walker in a paper read at the World Power Conference in London recently. "The use of direct current for high tension transmission purposes," stated Professor Walker, "would do away at once with so many of the difficulties, that it is exceedingly probable that the prophecy made by Lord Kelvin, many years ago, as to the ultimate triumph of direct current may yet come true." Undoubtedly, if we can get really reliable converting machinery which will give perfect service under all conditions of load the use of high voltage direct current is certain to come into general use for extremely long power lines.

As a means of converting high tension alternating current to direct current, the use of the modern thermonic

satisfactory service. The disadvantages of insulated floors and couplings, limited size of generator capacity and the complications introduced by series arrangements of generators and motors, outweigh the advantages especially where large quantities of power are concerned and for these reasons the system has not come into use in this country. In Europe, line voltages approximately 70,000 v. are in use with the Thury system and a transmission distance of 112 mi. (Montier-Lyons) has been reached. It is highly improbable that the Thury system will be developed to a much greater extent than it now is, but that direct current will ultimately replace alternating current for high voltage transmission purposes is extremely probable.

Present Day Transmission Problems

In the meantime, high voltage alternating current transmission presents many problems. The insulator problem continues to be one of the chief sources of difficulty, and although considerable progress has been made both in the design and manufacture of suspension type insulators, there still remains room for additional investigation on the electrical and mechanical effects influencing

leakage, resistance, deterioration, etc. Some flash-overs of insulator strings are still unexplainable and research work is being done to try to determine the cause and cure of these flash-overs.

The successful automatic operation of oil switches with relay protection at voltages as high as 220 kv. is an accomplished fact and this prevents to a large extent damage to insulators on account of flash-overs. The result of experience during the past year on the 220-kv. transmission lines in California is very encouraging. In the Northern and Southern California systems 220-kv. transmission seems to be an absolute necessity, due to the large amounts of power to be transmitted. Synchronous condensers are also proving valuable assets in voltage maintenance.

The One Million Volt Line

Just how much higher than 220 kv. transmission voltages will rise is a question which cannot be definitely answered at this time, although it seems as if 220 kv. might satisfy our needs. Mr. Thomas in his hypothetical 500 mi. transmission line assumed 220 and 245 kv. and his calculations indicate that power can be transmitted over this distance at those voltages with reasonable efficiency.

In connection with the development of a number of extremely high voltage testing sets there has been some mention lately of the possibility of a million volt transmission line. While it may be possible to build such a line, it is doubtful whether the expense of construction and maintenance will ever make it economically feasible and whether the transmission distances required in the future will make one million-volt transmission a necessity. It has been shown, that the conductor for a one million volt transmission line would have to be approximately 8 in. in diameter, in order to reduce the corona losses. While this is only one phase of the problem, it indicates to some extent the magnitude of such an undertaking. Experimental work however, is going on and if at some time in the future we discover the one million volt transmission line to be a necessity, the engineer will find a way to build it and operate it. We have great faith in the abilities of the engineer.

Operation of Converting Apparatus---II

Rotary Converters, Methods of Connecting, Voltage Regulation. By V. E. Johnson

IN THE PREVIOUS article of this series which appeared in the Aug. 15 issue, we discussed various methods of converting from alternating to direct current and vice versa, and described in detail the motor generator system of conversion. In this article we shall take up the subject of rotary converters.

A rotary converter is a machine which combines in one field structure and one armature the functions of both the alternating current motor and the direct current generator. Mechanically it is essentially a direct current generator to which has been added several slip rings through which the driving current is supplied from the a. c. mains direct or through transformers.

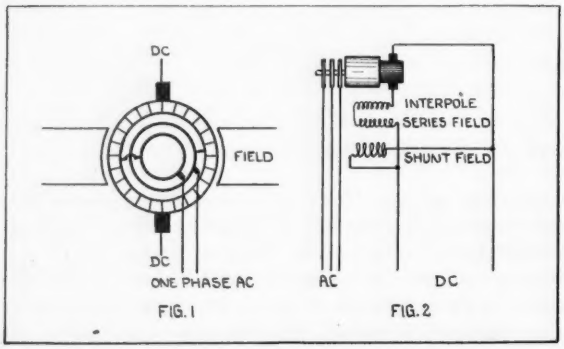


FIG. 1. TWO-POLE ARMATURE WITH PAIR OF SLIP RINGS CONNECTED TO OPPOSITE COMMUTATOR BARS
FIG. 2. CONNECTIONS FOR A THREE-PHASE ROTARY CONVERTER

In Fig. 1 is shown a two-pole armature, having a pair of slip rings connected to diametrically opposite commutator bars. Inasmuch as the generated potential is impressed on these rings without being commutated, a circuit connected to them would carry alternating current. In a multipolar machine, commutator bars having equal potential would be connected to the rings, so that there would be (for example) in an eight-pole generator, four connections to each ring.

An armature having connections as above could be used in several different ways. First of all, it could be driven as a generator, supplying direct current or alternating current, or both simultaneously. Secondly, it could be made to run as a direct current motor. While running under this condition, single-phase power could be taken from the slip rings. Lastly, it could be run from the slip rings as a single-phase revolving armature synchronous motor—and could at the same time supply direct current through the commutator. Under this last condition, it would be operating as a single-phase rotary converter—while under the one just previous it would be an "inverted" converter.

By using three or more slip rings connected to symmetrical points on the armature windings as referred to the poles, polyphase currents will be obtained if the machine be run from the d. c. end. On the other hand, if a polyphase power circuit be connected to the slip rings, the unit will run as a polyphase rotary, and will, as before, deliver direct current to an external circuit connected to the brushes.

Figure 2 shows in somewhat more detail the connections for a three-phase rotary. Such a machine may be started up from either end. If a. c. starting is used, the procedure roughly resembles that used in starting a synchronous motor generator set. If d. c. starting is employed, the method approximates that used in starting a synchronous motor set from the direct current end. A. c. starting induces high voltages in the field, and in order to prevent these rising to a dangerous and destructive value, a field break-up switch is often used. This splits the field up into separate field coils, or pairs of coils, and limits the potentials to those set up in one or two coils.

Rotary converters started from the a. c. end have inherently poor starting torque. In order to improve this, damper windings, similar in principle to those already

described under alternators, are placed around the pole faces. These also function to prevent "hunting" a phenomenon exactly analogous to the action of a "racing" governor.

Figure 3 shows the practical connections used for starting a polyphase converter from the a. c. end. Figure 4 shows the arrangement for d. c. starting.

Ratio Between D. C. and A. C. Voltages

The ratio between the d. c. and a. c. voltage in a rotary converter is fixed by the number of phases, and is not subject to alteration. The following tabulation gives the relation.

Voltage	Ratio of D. C. to A. C. in Rotary Converters
Single phase	100 d. c. v. equals 72 a. c. v.
Two phase	100 d. c. v. equals 72 a. c. v.
Three phase	100 d. c. v. equals 62.3 a. c. v.
Six phase (diametrical)	100 d. c. v. equals 72 a. c. v.
Six phase (double delta)	100 d. c. v. equals 62.3 a. c. v.

Voltage ratios in the above table hold true only at no load. At full load the direct current would be reduced by armature drop, some two or three per cent.

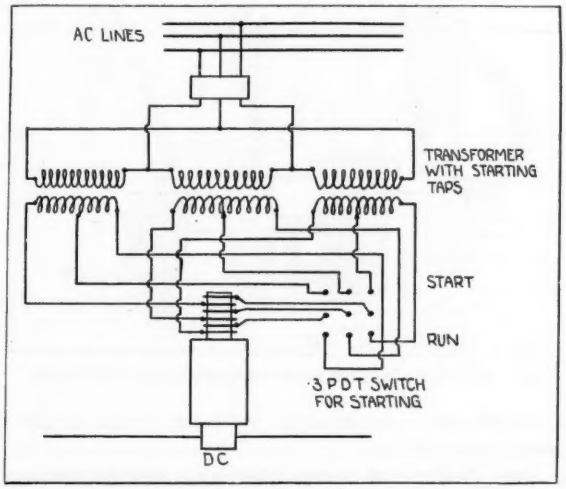


FIG. 3. DIAGRAM SHOWING CONNECTIONS FOR STARTING A POLYPHASE CONVERTER FROM THE A. C. END

There is also a more or less fixed ratio between a. c. and d. c. current flow. The following table gives this:

Voltage	Ratio of D. C. to A. C. in Rotary Converters
Single phase	100 d. c. amp. equals 1.50 amp. per ring
Two phase	100 d. c. amp. equals .75 amp. per ring
Three phase	100 d. c. amp. equals 1.00 amp. per ring
Six phase	100 d. c. amp. equals .50 amp. per ring

As the ratio between the direct and alternating voltages is fixed, special means are required for adjusting the direct current to meet circuit requirements, when fed from a constant potential a. c. source. These means, in general, consist of devices which raise or lower the ring voltage independently, and may be divided into (a) reactors, (b) feeder regulators, (c) boosters.

Figure 5 is a schematic representation of the method which employs reactors. The converter, considered from the a. c. end is essentially a synchronous motor, and can therefore have its power factor varied by means of field adjustment. If the field be increased above normal, the current taken through these reactors will lead the voltage, and the result will be that the rings will be subjected to a higher potential. This will result in higher d. c. pressure.

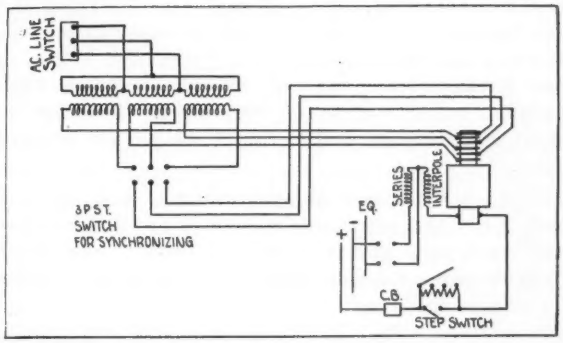


FIG. 4. ARRANGEMENT USED FOR D. C. STARTING OF POLYPHASE CONVERTER

If the field be weakened, the rotary will draw lagging currents through the reactors, and the ring voltage will be lowered, with a corresponding lowering of the direct current end. At unity power factor, the line voltage will approximately equal the ring pressure.

Inasmuch as the commercial d. c. voltages are comparatively low, it follows that the ring voltages are low. The result is that rotaries are almost invariably operated from the low side of transformer banks. Under such conditions, it is often convenient to design the transformers to have the necessary regulating reactance, and so eliminate external reactors as in Fig. 5. The result as far as regulation is concerned, however, is the same, and the direct current is adjusted by changing the actual ratio of the transformers which supply the rotary.

Rotary converters for railway and similar service, have compound windings on their fields, so that increased load produces increased excitation—and so in a large measure regulates the terminal d. c. voltage. Manipulation of the shunt field rheostat will also serve to adjust the outgoing line pressure.

Direct current manipulation by the above method is satisfactory when limited voltage variation is satisfactory. It cannot be applied to requirements which must have a wide range of adjustment. In the first place this would entail the use of high reactance which would result in inherently poor regulation, and an oversensitiveness to load changes. Furthermore, the voltage variation is obtained

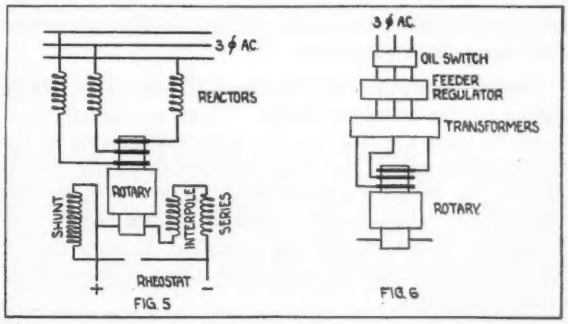


FIG. 5. CONVERTER PROVIDED WITH REACTORS FOR ADJUSTING THE DIRECT CURRENT VOLTAGE

FIG. 6. ROTARY CONVERTER ARRANGED TO OPERATE WITH A FEEDER REGULATOR

by drawing wattless current through the reactances, and thus imposes this extra load on the armature conductors. A rotary converter differs from a synchronous motor, in that it cannot carry wattless current, except in small amounts, without danger of overheating. This fact, in itself, effectually limits the use of the method outlined above.

Figure 5 shows reactance only in circuit. As a matter of fact, the circuit must contain more or less resistance, so that the element of ohmic drop must also be considered, in determining the ring voltage. If the leads are long,

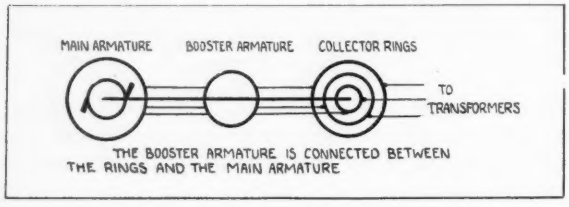

MAIN ARMATURE
BOOSTER ARMATURE
COLLECTOR RINGS
TO TRANSFORMERS
THE BOOSTER ARMATURE IS CONNECTED BETWEEN THE RINGS AND THE MAIN ARMATURE

FIG. 7. THE BOOSTER CONVERTER

considerable adjustment is obtained by the change in voltage due to the varying amounts of current drawn through this resistance. The amount of compounding obtained is affected by various other factors. Chief among these are the following:

(a) Ratio of series field strength to the shunt field. If the shunt field rheostat is adjusted so as to take slightly lagging currents at light load, then the series turns under full load will, if properly proportioned, cause the current to lead. If, on the other hand, the light load setting of the shunt field be such as to produce leading currents, then the added flux from the compounding cannot be so effective.

(b) As in a d. c. generator, the relative strength of the armature and field fluxes has considerable effect.

(c) The total internal drop in the rotary itself materially affects the terminal voltage.

In general, with from 12 to 15 per cent reactance in the transformers or external reactances it is possible to get a flat compound curve. It is not usually desirable to "overcompound" rotaries.

By proper field adjustment it is possible to maintain either constant voltage, or unity power factor. Both cannot be obtained simultaneously. This is no great drawback, for in many classes of service a drooping characteristic is desirable, because it reduces the flow of current under severe load conditions.

Feeder regulators may be used to vary the voltage applied to the converter rings. These are usually connected between the line and the high voltage side of the transformers, unless prevented by manufacturing limitations in the regulators themselves. Figure 6 shows this arrangement. Considerable flexibility is obtained by this scheme, but it complicates the operation, to some extent, and introduces additional apparatus which requires added maintenance costs.

On the other hand, this method permits the use of ordinary converters, in combination with standard regulators, so that the first cost is not prohibitive, nor is the time required to manufacture excessive.

In spite of the convenience of the method above, it is not as popular as that shown in Fig. 7. The apparatus there shown is the "booster converter." A booster generator is connected between the rings and the main rotary armature, and is so arranged that its voltage can be varied through a considerable range, and having switching arrangements so as to permit the auxiliary voltage to be either added to or subtracted from the total voltage.

Figure 8 shows roughly the cross section of a booster converter. The booster armature rotates within a field structure that is separate from the main field yoke, and which is magnetized independently of it. The current from the rings passes through the conductors of this portion of the machine. It will be seen that if the fields Fb be left unexcited, the a. c. voltage will be impressed directly on the tap coils of the converter itself. If, however, the booster conductors cut flux, they will have generated in them a voltage which will either add to or subtract from the ring voltage. In other words, the pressure on the rotary armature will be the resultant of the ring voltage and the booster voltage. By manipulating the fields Fb, any desired terminal voltage within the limits of the machine is obtainable.

There are no clearly defined lines as to where each type

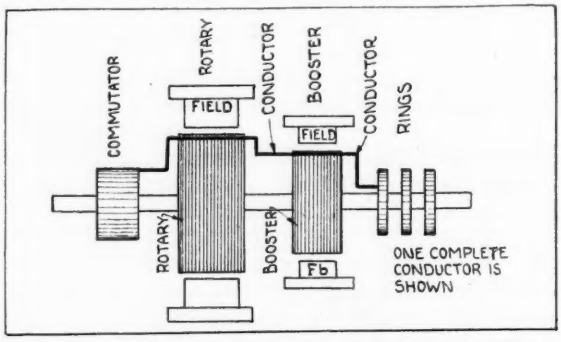


FIG. 8. CROSS SECTION OF THE BOOSTER CONVERTER

of rotary should be applied, but broadly the service is classified as follows:

(a) Plain shunt wound rotaries are used for ordinary industrial applications, for motors and lighting where there is no need of adjustable voltage.

(b) Compound wound converters are used for railway service, where it is desirable to raise the voltage during heavy load periods to compensate for feeder drops.

(c) Feeder regulators are used on rotaries for special applications, and are often used in experimental or educational work.

(b) Booster converters are used for industrial service where there is required considerable voltage variation.

It is customary to use commutating or inter poles on modern rotary converters. These function exactly as in the case of direct current generators. They are connected in the same way, and require no special discussion.

EXERCISE CARE in adjusting glands, setting up the adjusting nuts only enough to prevent leakage. Further tightening results only in undue friction, wear on the packing and possible scoring of the rods. It should be remembered that as the stuffing box in the partition between the crankcase and the yoke is not required to hold pressure, but only to prevent oil from being carried along the rod into the cylinder, its gland can be run quite loose.

Use of Slings for Heavy Parts

SAFETY MUST BE THE WATCHWORD. PROTECTION MUST BE ASSURED THE OPERATOR, OTHER WORKMEN AND EQUIPMENT

IT IS AN interesting thing what extreme measures some crane operators will take in order to abuse the equipment that is in their charge. Operators will tie up circuit breakers, wire around fuses, neglect oiling and allow slip-rings and commutators to become so pitted and burned, that the motors will not run. They will plug the motors continually and will attempt to run motors which are connected mechanically in opposite directions. They will screw down bearing caps as tight as possible and then blame the motors for having no "pep." One operator changed the wiring of two series motors so that they were thrown across the line on the first controller point, so that he would not have to move the operating levers so far. A long feed line of small size, which cut down the current on starting, saved the motor from being ruined instantly.

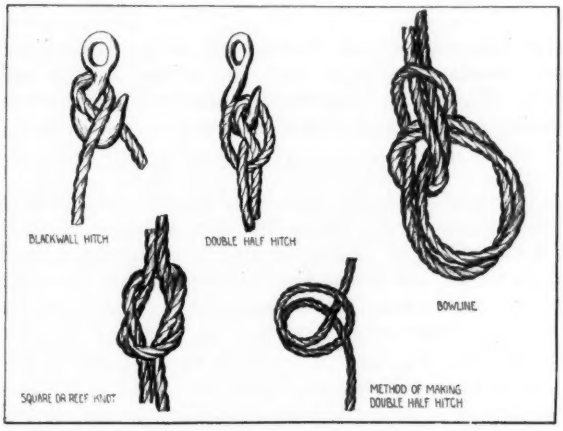


FIG. 1. VARIOUS TYPES OF ROPE KNOTS

In order to insure the safety of equipment, product and men, the General Electric Co. has prepared a complete code of instructions to crane followers and others in the use of slings and making hitches. Much of this has been incorporated in the material which follows.

Too often chances are taken in estimating the weight of material to be handled by slings and cranes. If there is any doubt as to the weight, it should be calculated. One of the most important "safety first" rules is to allow nobody to walk under or stand under a suspended load. It is also contrary to good practice for any one to ride a load.

Before a lift is made, remove all loose pieces that may be lying on work to be lifted. For instance, in hollow castings, look inside for loose pieces such as bolts, straps, blocking, etc.

Eyebolts should not be used on angular lifts unless absolutely necessary, as the capacity of the eyebolt drops rapidly as the angle of pull increases. For instance, a ½-in. eyebolt will carry with safety 1100 lb. straight lift but if the lift is at an angle of 90 deg., the eyebolt will carry only 37 or 38 lb., or only about one-thirtieth of what it would carry at a straight lift.

Do not neglect to place pads on all sharp corners with which ropes, slings and chains might otherwise come in contact, especially in cases where the slings might slide during the lifting operation. Chains, hooks, shackles, bolts, etc., should be inspected to see if repairs or replacements are needed. Never use a chain if the links do not work freely within one another, since such chain has been overloaded or misused. If the parts show long wear, anneal them. When badly worn or bent, scrap them. Use neither wire rope nor manila rope that has become badly frayed or worn in spots, and do not use a wire rope having a sharp fixed kink.

Chain hoists should not be loaded beyond their rated capacity, for that will cause the links in the chains to

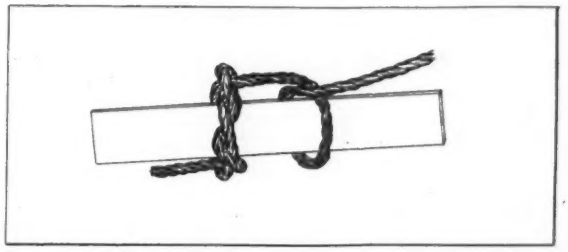


FIG. 2. HITCH USED FOR HOISTING SHAFTS OR TIMBERS IN A VERTICAL POSITION

kink and bind. Hitches should not be made with the load chain and hook, for that causes kinks in the chains and weakens the hooks.

ADVANTAGES OF ROPES AND CHAINS

There is a great difference between ropes and slings used for hoisting. In ropes the wear can always be seen by the strands becoming frayed, loose or cut. A chain,

Diam. in Inches	Vertical Load		60° Angle		45° Angle		30° Angle	
	For General Use	For Molten Metal	For General Use	For Molten Metal	For General Use	For Molten Metal	For General Use	For Molten Metal
⅜	1,500	1,200	1,275	1,000	1,050	800	750	600
½	2,400	1,900	2,050	1,600	1,700	1,350	1,200	950
⅝	4,000	3,200	3,400	2,700	2,800	2,200	2,000	1,600
¾	6,000	4,800	5,100	4,000	4,200	3,300	3,000	2,400
⅞	8,000	6,400	6,800	5,400	5,600	4,400	4,000	3,200
1	10,000	8,000	8,500	6,800	7,000	5,600	5,000	4,000
1⅛	13,000	10,400	11,000	8,800	9,000	7,200	6,500	5,200
1¼	16,000	12,800	13,500	10,800	11,000	8,800	8,000	6,400
1⅜	19,000	15,200	16,000	12,800	13,000	10,400	9,500	7,600
1½	22,000	17,600	19,000	15,200	16,000	12,800	11,000	8,800

TABLE I. SAFE LOADS FOR MANILA ROPE, EXPRESSED IN POUNDS

except for a few bruises, will not show any signs of weakness, although it may be full of small cracks which cannot be seen by the naked eye, or it may be much crystallized by long use. Under these conditions a chain is rapidly becoming weaker with each lift, until it finally gives way, letting something fall on the man who used it, or, as is more frequently the case, on some innocent shopmate.

Whether anyone is hurt or not there is always a loss. Sometimes it may be only a rough casting but often it is a piece of finished apparatus on which much time and labor have been spent. Care is the first consideration and speed

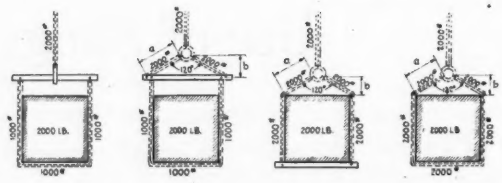
Cir. in Inches	Diam. in Inches	Vertical Load		60° Angle		45° Angle		30° Angle	
		For General Use	For Molten Metal	For General Use	For Molten Metal	For General Use	For Molten Metal	For General Use	For Molten Metal
1	5/16	120	DO NOT USE	100	DO NOT USE	85	DO NOT USE	60	DO NOT USE
1½	½	250		210		175		125	
2	5/8	360		300		250		180	
2¼	¾	520		440		360		260	
2¾	⅞	620		520		420		300	
3	1	750		625		525		375	
3½	1⅛	1,000		850		700		500	
3¾	1¼	1,200		1,025		850		600	
4½	1½	1,600		1,350		1,100		800	
5½	1¾	2,100		1,800		1,500		1,050	
6	2	2,800		2,400		2,000		1,400	
7½	2½	4,000		3,400		2,800		2,000	
9	3	6,000		5,100		4,200		3,000	

TABLE II. SAFE LOADS FOR SINGLE ROPE OF PLOW STEEL, EXPRESSED IN POUNDS

next. Suitable racks should be provided to hang chains and slings on and when not in actual use, chains should be kept on these racks. When not following cranes and making hitches, the followers should be inspecting these slings to detect weaknesses and sorting out the bad ones to have them repaired.

Wire cable slings occupy an important place in hoisting and have been found satisfactory when carefully used. A wire cable sling should not be used singly when hooked by a spliced eye. When the weight is sufficient, the cable is likely to untwist, thus allowing the splices to open and slip. Always use such slings double and where sharp corners or rough castings exist, protect the cable by pads. Another method of protecting the cable is by two loose metal blocks. These should be free to adjust themselves.

In using slings of any kind, see that they are properly laid, that is, see that one rope does not lie on top of the other, as this will prevent proper equalization, putting an undue strain on the outer rope. It often happens when a rope sling is used double, that the ends of the rope are passed through the doubled part, as when placed around a casting and unless this is done carefully, instead of having the strength of two parts of a rope, as supposed, it can be so slipped around the casting, or other piece being lifted,



SAFE LOAD IN POUNDS FOR SLING CHAINS
LOAD HANGING ON TWO STRANDS OF CHAIN FORMING ANGLES SHOWN

		STRAIGHT	60°	90°	120°	150°	170°
¼"	¼ TON	1000	866	707	500	258	87
9/32"	½ TON	2000	1732	1414	1000	516	174
5/16"	¾ TON	3000	2598	2121	1500	774	261
⅜	1 TON	4000	3464	2828	2000	1032	348
7/16"	1½ TON	6000	5196	4242	3000	1548	522
½"	2 TON	8000	6928	5656	4000	2064	696
9/16"	2½ TON	10000	8660	7070	5000	2580	870
⅝"	3 TON	12000	10392	8484	6000	3096	1044

TABLE III. SAFE LOAD IN POUNDS FOR SLING CHAINS

as to have actually only the strength of one part. Never loop manila rope slings and wire cables through each other. The cables, being much thinner will cut the rope, causing serious accidents and delays.

Crane Brakes Should Be Tested

Before lifting heavy loads by means of a crane, always test the crane brakes to see that they are in good condition and will hold. When lowering loads, limit the speed, which should not exceed the hoisting speed of the crane for the same load. Take particular care to apply the brakes gradually when bringing the load to rest. The ordinary hoisting speed for a 30-T. motor operated crane is about 18 ft. per min. and for a 50-T. crane about 12 ft. per min. with the rated load. Stopping the load at such speeds within a short distance may double the stress on the slings and crane.

When a weight is lifted by one or more slings connected to the crane hook and making an angle with the work, the increase in the stress of each sling must be

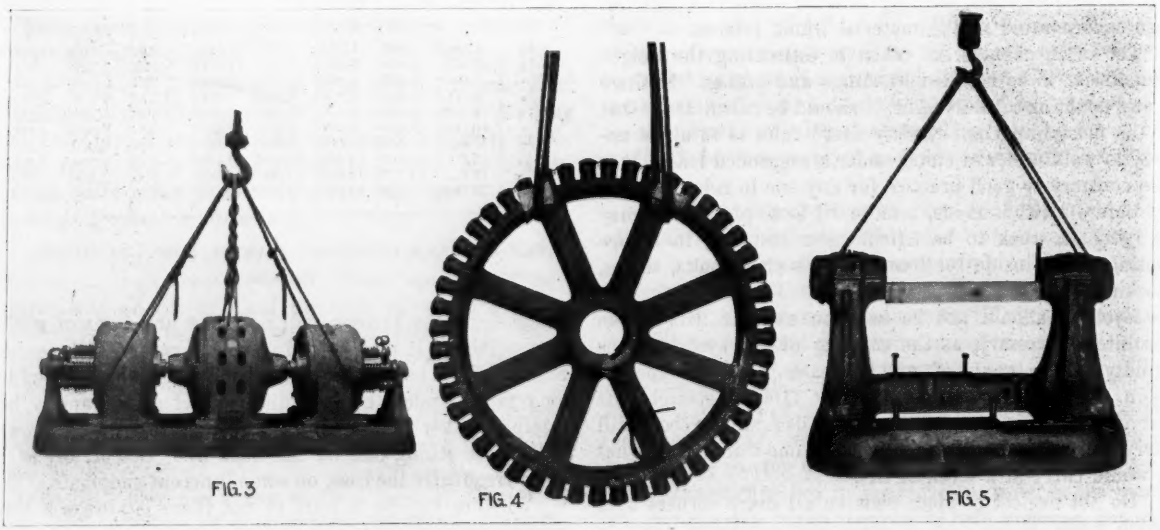


FIG. 3. RIGHT WAY TO LIFT A MOTOR-GENERATOR SET FIG. 4. CORRECT METHOD OF LIFTING A REVOLVING FIELD
FIG. 5. STANDARDS SHOULD BE BRACED BEFORE MAKING LIFT

considered. On account of this angle between the work and the sling, the stress on each sling is greater than half the total load and increases rapidly as the angle between the sling and the work is decreased. An angle of 45 deg. between the sling and the work makes the stress in each sling three-fourths of the total weight and the collapsing force between the two points of attachment to the work is equal to one-half the weight. This collapsing force acts in a direct line between the points of attachment. If the work is ring shaped, it would tend to deform the ring. A spreader of sufficient stiffness should be used between these points to resist this collapsing force. It will be seen that eyebolts are not suitable for attaching the slings to the work unless a spreader is used to relieve them of this side pull, which would put a heavy bending moment on the shank of the bolt.

Reducing the angle between the sling and the work to 30 deg. makes the stress in each sling equal to the total weight and the collapsing force is also equal to the total weight.

It should be understood that to obtain the greatest strength from an eyebolt, it must fit reasonably tight in the hole into which it is screwed and the pull applied in a line with the axis of the screw. Eyebolts should never be used if considered the least faulty. They should not be painted when used for miscellaneous lifting, as paint is likely to cover up flaws. They should be tested occasionally by tapping gently with a hammer while held in the hand. If it does not impart a good ring, it should not be used. Where a bolt is to be used for anything like its maximum load, it should be screwed in tight with a bar.

Use of Lag Screws in Hoisting

Wood or lag screws when made in the form of an eyebolt, should never be used to hang any hoisting tackle on. Wherever it is possible, the safest way to hang such tackle is by passing the shank of an eyebolt through the floor or beam, properly protecting the wood by a large plate washer and nut. It frequently happens that a chain or rope sling can be used by passing it over a properly secured timber.

It is advised and urged in every case where a person is in doubt as to the weights to be lifted or methods employed, to seek advice from his foreman. It is also suggested and urged that all irregular shaped castings and, in fact, all castings weighing over a ton, should have the gross weight marked in plain figures for the guidance of those engaged in handling or lifting pieces. It is always safer to over-estimate a weight than to under-estimate it and it is always safer to use slings of ample lifting capacity than those about which one is in doubt.

Other defects besides those in lifting apparatus will occasionally be discovered, such as a cracked arm of a flywheel, or other similar pieces. If this defect is discovered by the person originally handling the piece, he should call his superior's attention to it immediately upon making such discovery.

It is not unusual to open up a hook without taxing it to its full rated capacity by simply setting the slings carelessly so that the load bears too far out on the point of the hook. Sometimes, in slinging the load, too many strands of the sling are passed through the hook. This causes the hook to open, due to the side strain of the sling when the hook really has capacity enough to carry 3½ times its rated capacity, if the load is properly slung and suspended.

Skip Hoist Used Without Overhead Storage

RECENTLY THERE has been installed an ash skip hoist of novel design at the Chicago Ave. boiler plant of Montgomery, Ward & Co., Chicago, Ill. Up to the time of this installation all the ash at this plant was elevated from the boiler room and then shoveled into a railroad car, this requiring a comparatively large force of laborers.

With the new skip hoist in operation the services of but one man is required to handle the ash from the time it is delivered from the boiler house until it is loaded into a railroad car. The ash is now brought out of the

SWINGING SPOUT FACILITATES LOADING CAR WITH ONE SPOTTING

boiler room in narrow gage pivoted dump-cars from which it is dumped into a concrete hopper. This hopper has a sloping bottom with a gate near its lowest point.

Ash is discharged through this gate into the skip hoist bucket, which is then hoisted a distance of 79 ft. No storage capacity has been provided at the top of the skip hoist frame, instead the ash is discharged directly into a chute through which it is spouted into a railroad car spotted on a spur which dead ends near the base of the hoist frame work.

This ash spout is made in two sections. The upper section is fixed and stands at an angle of slightly more than 45 deg. with the horizontal. At its lower end is an elbow which turns the direction of ash flow directly downward into the lower section of the spout. This lower section is carried on a small boom and pivots, at its upper end, about a turnhead in such a manner that it is flexible in both the vertical and horizontal planes.

This arrangement results in a great advantage because

by swinging the lower section of this spout it is possible to feed to both ends of a 40 ft. railroad car without changing the car's position. The spout can also be swung around so that it will clear a box car or a locomotive. Movement of the spout is accomplished by means of two sets of wire cables and hand operated winches. The weight of the spout is counterbalanced for movement in the vertical plane. At the lower end of the movable spout is a gate which is operated by a cable from the ground level. The hoist, which is rated at 30 T. per hr., is equipped with safety devices and it can be stopped and held at any point in its travel.

Engineering and construction on this hoist was carried out by the Weller Mfg. Co., of Chicago, Ill.

Useful Oil Weight Chart

By W. F. Schaphorst

ON ACCOUNT of the considerable variation in weight of oils there is often confusion as to the number of pounds of the different kinds of oil in a given container.

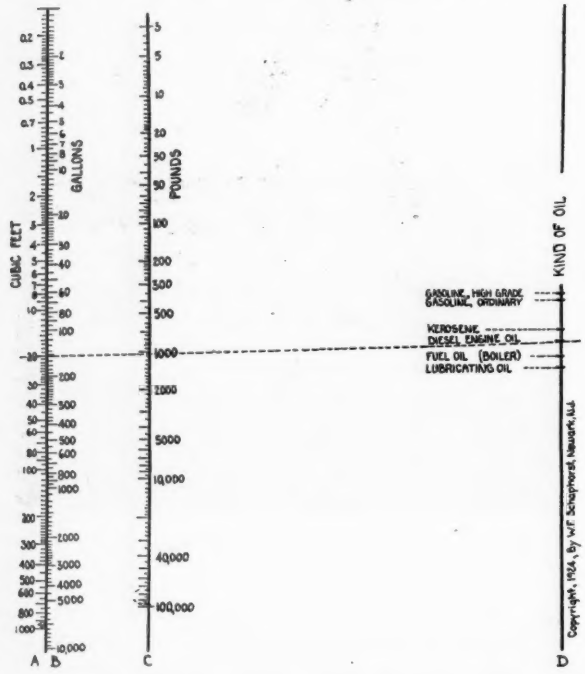


CHART FOR CONVERTING OIL VOLUMES TO WEIGHT AND VICE VERSA

It is desirable to know the weight because heat value is almost invariably given in B.t.u. per lb.

This chart will be found useful for quickly determining the weight of almost any number of cubic feet or number of gallons for any of the common oils: high grade or ordinary gasoline, kerosene, Diesel engine oil, fuel oil and lubricating oil.

For example, what is the weight of 20 cu. ft. of Diesel engine oil?

The dotted line drawn across the chart shows how the problem is solved. Connect the 20 in Column A with the point in Column D corresponding with Diesel engine oil and the intersection with Column C gives the weight as about 1006 lb.

If the quantity of oil is given in gallons, use Column B instead of Column A. Thus Column A-B can be used as a conversion scale; for example: 20 cu. ft. is equivalent almost to 150 gal.; 1000 cu. ft. is equivalent to 7500 gal., etc.

Inversely if the number of pounds is known and the kind of oil is known a line through the known points gives us an intersection in Column A-B which tells the volume.

For those who prefer to make computations in longhand or on a slide rule, this chart is based on the following weights per gallon.

Gasoline, high grade	6.0 lb. per gal.
Gasoline, ordinary	6.12 lb. per gal.
Kerosene	6.81 lb. per gal.
Diesel engine oil	7.09 lb. per gal.
Fuel oil	7.5 lb. per gal.
Lubricating oil	7.78 lb. per gal.

Loosely Drawn Contracts Invite Litigation

Implied Warranty of Fitness of Machinery For Purpose Purchased. By Leslie Childs

WHEN and under what circumstances, a manufacturer impliedly warrants the fitness of his product for the purpose purchased is a question of particular importance to buyers of machinery and mechanical equipment. Of course each case of this kind must necessarily be decided in the light of the facts involved, but generally speaking, the rules governing situations of this kind may be summarized as follows.

Where a manufacturer sells an article, being advised of the purpose of its purchase, so that the buyer relies upon the judgment and skill of the manufacturer relative to its fitness, there will arise an implied warranty of fitness. If, on the other hand, a known described and definite article is ordered and the manufacturer supplies it in accordance with the terms of the contract, there will be no implied warranty of fitness, even though the manufacturer is advised of the purpose of the purchase.

The application of this rule of law is illustrated in an interesting and instructive manner in the Grand Avenue Hotel Company vs. Wharton et al., 79 Fed. 43. The facts and circumstances which culminated in the action being, in so far as material to this discussion, as follows.

A Case in Point

In this case the defendant, hotel company, was engaged in operating a hotel in Kansas City, Mo., and the plaintiffs were manufacturers of boilers. The defendant ordered of the plaintiff two boilers of 150 hp. each at a price of $3600, which covered installation. These boilers were of a well known class, and the contract of sale contained full particulars and specifications of the material and construction to be used in their manufacture.

In strict accordance with this contract the plaintiffs shipped and installed the boilers. But in operation they proved unsatisfactory because of the fact that the defendant, owing to its location, was compelled to use the muddy

water of the Missouri River. This water, it appears, deposited sediment filling the boiler caps, causing incrustations which reduced the heating capacity. Also, as was to be expected, these caps when filled with sediment burst, which required that fires be drawn and replacements made, which seriously interfered with the heating of the hotel, the purpose for which the boilers were purchased.

In the face of these facts the defendant declined to pay for the boilers, claiming that there was an implied warranty of their fitness for the use of muddy water of the Missouri River by the manufacturer. This contention was based on the ground that, as the manufacturer knew at the time the contract was entered into that the defendant would of necessity have to use the Missouri River water, it impliedly warranted the boilers as being adapted for this use.

On the other hand, the plantiffs, manufacturers, took the position that they had supplied a known, described article in strict conformity with the contract and that, as there was no express warranty of the fitness of the boilers for the use of the muddy water of the Missouri River, the defendant must be held to have assumed that risk.

The dispute between the parties culminated in the filing of the instant action by the plaintiffs in an attempt to recover the price of the boilers. Upon the trial of the case in the lower court the plaintiffs recovered a judgment. From this holding an appeal was taken to the higher court where in affirming the judgment, and holding that there was no implied warranty, relative to the fitness of the boilers for using the muddy water of the Missouri River, it was, among other things, said:

What the Court Decided

"Here the purchaser contracted for a definite, well-known kind of boiler * * *. The specifications as to size, form, material, and every detail were minute, and embodied in the contract. The manufacturers were obligated to deliver exactly such boilers as were described and contracted for, and could not, under the contract, deliver anything different.

"There is no claim that the boilers did not in every respect conform to this contract and specifications, nor any claim that they were defective, either in respect to workmanship or material. The purchaser did not exact a warranty that the boilers would operate with the muddy waters of the Missouri River, and therefore assumed that risk itself. * * *"

In the light of this decision, which is one of force and value on the point, it is obvious that where machinery is purchased for a given purpose some care should be used in respect to warranties relative to its fitness. If the buyer is positive of the fitness of the article for the purpose purchased, neither an implied nor positive warranty may be necessary. On the other hand, if there is any doubt about the fitness of the article the buyer should, for his own protection, place the matter before the seller in such a light as to create an implied warranty, or better still demand of the latter an express warranty of fitness. Certainly the point is one of great importance where machinery of doubtful utility is being purchased and should be attended to in a prudent manner when the contract is being entered into.

Summer and Winter Safety Hazards

HEAT exhaustion is a cause of considerable apprehension to employers of labor at this particular season. This condition is not uncommon among workers during the summer months, particularly those working around furnaces. In the cities along the Atlantic seaboard, where the relative humidity is high, this condition is accentuated. Thus writes Dr. Lorne E. Hastings, medical director, the J. G. Brill Co., Philadelphia, Pa., in a recent publication of the National Safety Council.

Another predisposing factor to heat exhaustion, is the use of alcoholic beverages, particularly the noxious grade usually peddled by bootleggers and the various amateur brews. Some characteristic symptoms of exhaustion are dizziness, headache, vomiting and usually pronounced muscular cramps.

Closely allied with heat exhaustion but differing in its effect is the sun stroke. One of the principal differences is the temperature of the victim. In heat exhaustion the temperature is normal or sub-normal, while in sun stroke thermic fever is present, that is, a high temperature, ranging from 105 to 108 or even higher. The temperature of work places has an important bearing on seasonal plant hazards. Probably the most comfortable temperature for the average healthy adult while at work is between 60 and 70 deg. F. For persons engaged in strenuous physical labor, a lower temperature is preferable. It is, of course, desirable to avoid extremes of both heat and cold.

Attention should be paid to supplying plenty of cool, fresh air to the work shops when natural ventilation is inadequate. The windows should be open, of course, and the air kept in motion. Despite special cooling devices, screens, water cooled furnace doors and the like, heat exhauston sometimes occurs when men are exposed to extreme heat.

An average relative humidity of between 55 and 65 per cent is the most healthful and therefore should be used as the standard although it is not always practical in industrial plants.

Turning to winter, it is found that some of the seasonal hazards are smallpox, frost bite and, of course, the usual respiratory diseases, ranging from catarrhal conditions to pneumonia. These ailments are more prevalent during the winter months because of the lowered vitality of the patients which increases the suceptibility to colds. These colds may be simply rhinitis, or cold in the head, pharyngitis, tonsilitis, pleurisy or pneumonia, resulting in much loss of time from work.

Cases of frost bite may be divided into three classifications. Those of the first class are characterized by redness and swelling of the skin. In the second degree, the symptoms of the first class are present, plus blebs or blisters. In the third degree, there is deep ulceration and sometimes gangrene. The third degree is seldom met with in industry but the other two are comparatively common.

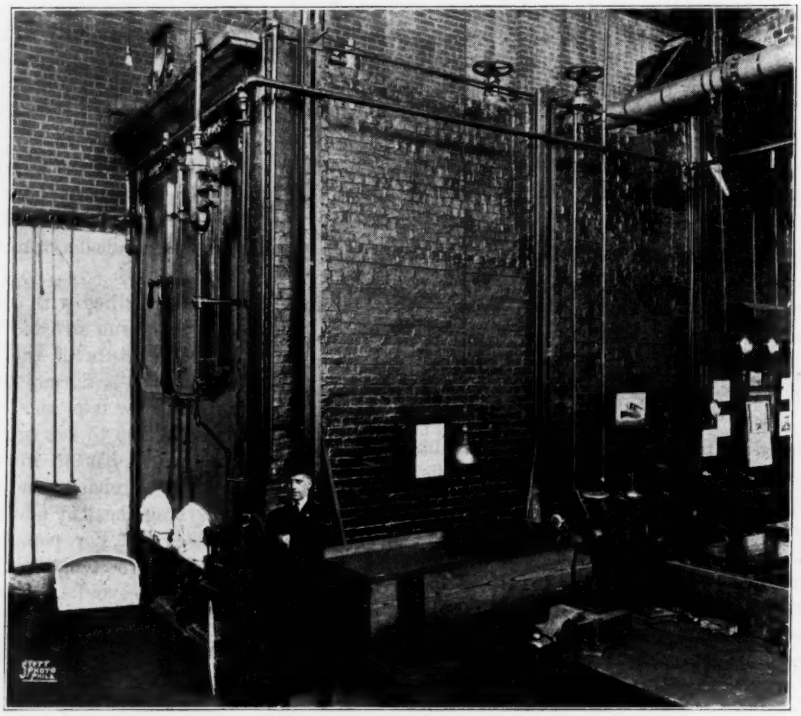
Experience shows that in the winter men show an increased tendency to bump themselves and drop objects on their feet. In warm weather many of these injuries would be of little consequence but in cold weather these contusions and abrasions are greatly accentuated. Injuries of this class can be prevented only by educating the men to be more careful.

Cleanliness Makes Boiler Room Attractive

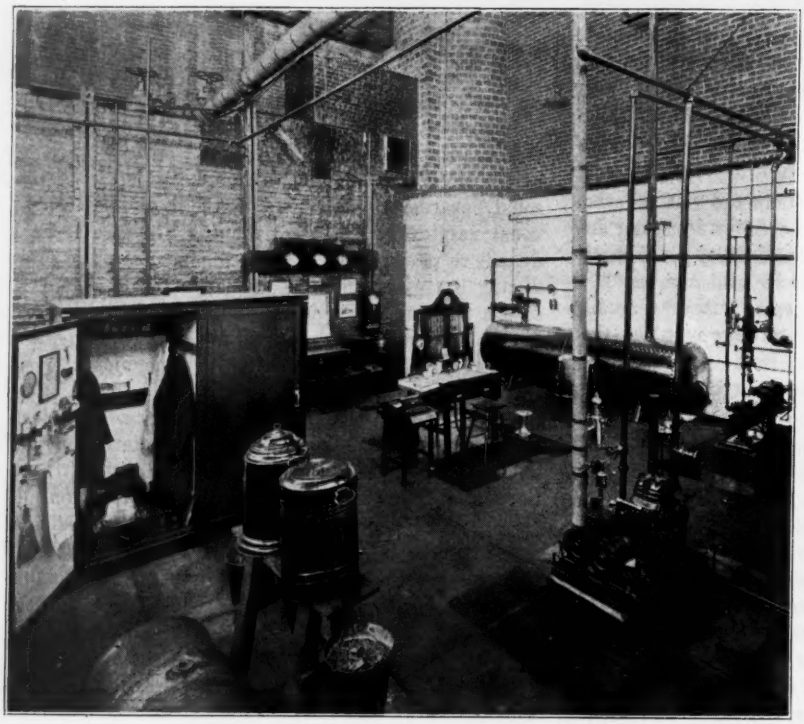
"A Place for Everything and Everything in Its Place" Is Evidently the Rule in This Philadelphia Plant

SHOULD you have the pleasure of visiting the boiler room of the Ferguson Carpet Company in Philadelphia your attention would immediately be attracted by the clean and orderly condition of the plant.

This is not a show plant in any sense of the word. The boiler is worked hard and the equipment is not elaborate, only the instruments and tools which have been found valuable in the every-day work of the plant are to be found here, but each is located in a convenient place and tools are always in chests or on hooks in first-class shape for immediate use.



Principal mechanical equipment of the boiler room consists of a 250-hp. Coatesville return-tubular boiler, a Worthington boiler feed pump and a Platt well pump. A Sellers injector is installed as a standby boiler feeder and a Spencer damper regulator controls the draft in the furnace which is fired with bituminous coal. As the factory is still growing, more equipment will be required.



All the furniture in the boiler room was made by the chief engineer, Louis W. Rawson, who also planned the entire layout and is emphatic in his statement that "keeping up the condition of this plant is no more of a task than the regular routine of things in any plant. It is the part of every engineer in justice to his profession to keep not only an efficient running plant but also a clean plant; it has a wonderful reflection."

Motor Drive for Ammonia Compressors*

SERVICE REQUIREMENTS MUST BE CAREFULLY CONSIDERED IF MOST ECONOMICAL TYPE OF MOTOR IS TO BE SELECTED. BY PAUL SCHLINGMAN

IN THE selection of the type of motor for an electrically driven ice plant, the same careful study and consideration is required as in the selection of prime movers in other industries. Some of the important factors bearing on the selection are: First cost, class of power contract offered by the power company, floor space available, whether the compressors will be required to operate at variable speeds or at all times at constant speed, whether the motors are to be direct connected, belt driven or chain driven, and whether the compressors are to be slow or high speed machines.

Inasmuch as the majority of ice plants being installed today use alternating current the discussion will be confined to this type of equipment. This does not mean, however, that the use of direct current in ice plants is impractical or impossible.

USE OF SQUIRREL CAGE MOTORS

From the standpoint of first cost, the use of a squirrel cage type of motor is the least expensive. The use of this type of motor, however, is confined mostly to small belt-driven compressors where operating conditions require only constant speed and when the compressor can always be started on a bypass. The general purpose squirrel-cage induction motor when started by means of a starting compensator will develop a starting torque varying as the square of the impressed voltage with starting currents drawn from the line ranging from about 72 per cent of normal current down to about 16 per cent of normal current, depending upon the design of the compensator. Thus when a compensator is used, the starting torque of the motor can be reduced to approximately the value required by the compressor and the current taken from the line correspondingly decreased. This type of motor will develop a starting torque ranging from 115 per cent to 150 per cent of full load torque, when thrown directly across the line and without the use of a compensator, with a starting current corresponding to full load starting torque of 3½ to 5 times full load current. Such a method of starting may or may not be objectionable from the power company's standpoint.

Development of the small automatic and semi-automatic ice plant has created a demand for a simple and reliable motor which will develop a starting torque sufficient to start the compressor under all possible conditions of operation without resorting to the use of the bypass or other means of relieving compression, and at the same time not draw a current from the line in excess of the values specified by the Power Club and the National Electric Light Association. There has recently been placed on the market such a motor. This motor has a double squirrel-cage winding and is free from all movable starting devices likely to give trouble. It is quite similar to the ordinary squirrel cage motor.

In some cities the power companies limit the use of squirrel-cage motors. Therefore it is advisable to consult the power company and also to confer with the motor manufacturer before actually purchasing the motors. A number of power companies have a penalty clause in their contracts for power factors below 80 per cent; others have a penalty and bonus clause in their contract regarding power factor. These are also factors which must be considered in the selection of motors.

WOUND ROTOR AND BRUSH SHIFTING MOTORS

Usually, the slip ring or wound rotor type of induction motor is used on medium size machines and where varying speed is required. This type of motor is more expensive than the squirrel-cage type and is not very efficient when operating at reduced speeds. Figure 1 shows the per cent power factor and efficiency at constant torque plotted

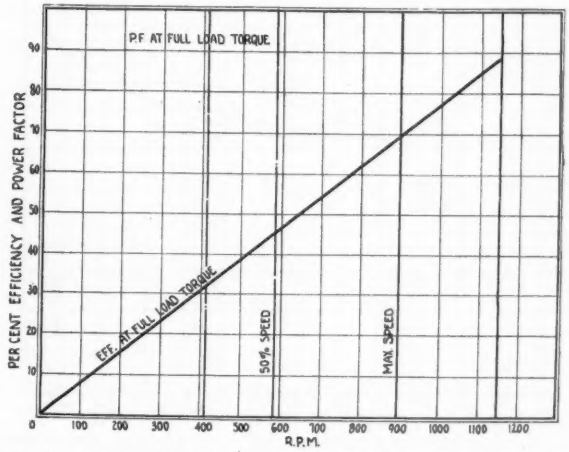


FIG. 1. EFFICIENCY OF A WOUND ROTOR MOTOR FALLS OFF RAPIDLY AS SPEED DECREASES

against speed in revolutions per minute. These curves apply to a 50-hp., 1200-r.p.m., 220-v., 3-phase, 60-cycle, constant torque, varying speed, slip ring motor.

There is still another type of adjustable speed motor to be had, known as the brush shifting type. This motor is still more expensive than the slip ring type, but its use can readily be justified where conditions of operation demand reduced speed operation of different values for long periods of time.

This type of motor has shunt characteristics and is rated on a constant torque basis. Its usual speed range is 3 to 1, the speed adjustment being obtained by shifting the brushes on the commutator. The starting torque varies from 150 per cent to 200 per cent of the full load torque with the brushes set at the low speed position. The starting current under these conditions ranges from 125 to 160 per cent of full load current. The maximum running torque at high speed is approximately 350 per cent. This type of motor operates at speeds above and below synchronism, the 900-r.p.m., 8-pole motor having a speed range from 415 to 1250 r.p.m.

As a comparison of characteristics between this type of motor and a motor of similar rating of the slip ring

*Abstracted from a paper, "The Application of Electric Energy to the Modern Ice Making and Refrigerating Plant," delivered before the Western meeting of the American Society of Refrigerating Engineers, at Cleveland, May 27, 28 and 29.

type, the author would refer to the curves in Figs. 1 and 2. The brush shifting type motor has an efficiency at full load torque at low speed, synchronous speed and maximum speed of 73, 85 and 85 per cent, respectively, and corresponding power factors of 73, 79 and 97 per cent. The corresponding values of efficiency of a wound rotor motor operating at corresponding speeds by means of secondary resistance control are 31.5, 68 and 88 per cent, respectively, with power factors at 90 per cent at all speeds. The maximum speed of the 50-hp. slip ring motor at full load is 1150 r.p.m. and this type of motor is usually not operated at speeds below 50 per cent of full load speed. At this point the efficiency is 44 per cent.

As a general rule the larger installations use the synchronous motor for driving the ammonia compressor and it is usually desirable to direct connect the motor to the compressor either by mounting the rotor directly on the compressor shaft, or by means of a solid flange coupling, in which case the motor is furnished with its own sub-

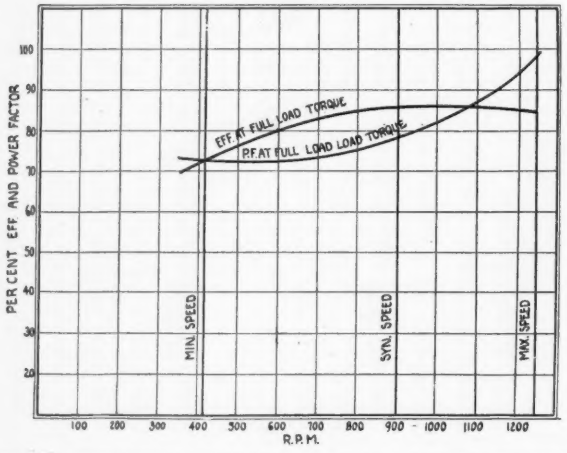


FIG. 2. EFFICIENCY CHARACTERISTIC OF A BRUSH SHIFTING TYPE MOTOR

base, two pedestal bearings and shaft. The tendency today is to mount the motor directly on the compressor shaft and to embody all the flywheel effect in its rotor, thereby eliminating the separate flywheel usually required with the compressor. This combination makes a neat and compact unit.

Control Equipment for Various Types of Motors

Each of the several types of motors referred to require a different type of control. With the squirrel-cage motor it is only necessary to supply a starting compensator and in some cases this is not even required. This type of starter should be provided with overload relays and undervoltage trip and it is desirable, although not essential, to have also a disconnecting switch and an indicating ammeter. Where squirrel-cage motors are thrown directly across the line it is desirable to use either a magnetic contactor type of switch equipped with thermal overload relay protection or an oil circuit breaker with overload relays, the selection depending somewhat on the size of motor.

For the slip ring type of motor the control equipment usually consists of a drum type controller and an external resistor for the rotor circuit and an oil circuit breaker or magnetic contactor type of switch in the stator or primary circuit either of which should be provided with overload protective features. If the motor is to operate at constant speed only, then the rotor resistor need only be designed for 2 min. starting duty; if variable speed operation is required the resistor must have greater carrying capacity and should, as a rule, be suitable for 50 per cent speed reduction for continuous operation.

Drum controllers are, as a rule, not intended to open the primary circuit of the motor, and it is for this reason the use of an oil circuit breaker or magnetic switch is recommended. In addition to the overload features on this switch, it is desirable to have an interlocking device between the primary switch and the drum controller to prevent closing the primary switch, except when the controller handle is in the off position. This feature guards against starting the motor with all the resistance cut out of the rotor circuit.

Control equipment for the brush shifting type of motors consists merely of a magnetic type of switch with thermal overload relays and under voltage protection. The motor is started on full voltage by means of a push button and with the brushes located as a rule in the low speed position.

Control Requirements for Synchronous Motors

Synchronous motors require somewhat more elaborate control equipment. This statement applies particularly to the larger direct connected motors. There are a number of standard synchronous motor control panels from which selection can be made; these may be manually operated, they may be remote control semi-automatic or they may be full automatic. In the opinion of the author the simplest form of synchronous motor control panel consists of one equipped with a magnetic contactor for the primary circuit, a field contactor, and rheostat operating mechanisms for the motor field and the exciter. With this type of starter the motor is thrown directly across the line by merely closing a push button which automatically closes the primary contactor; after a certain time interval the field contactor also automatically closes. Some of the larger central stations have permitted the use of this type of starter for motors as large as 600 hp. With this type of starter it is necessary to use an oil circuit breaker with overload relays ahead of the contactor, since the interrupting capacity of contactors is usually very limited and in addition they are not provided with over load features.

If throwing the motor directly across the line is not permissible, then a panel equipped with a self-contained starting compensator, mounted back of the panel and operated from the front, a double-pole field switch with discharge resistance clips, an alternating current ammeter, a field ammeter and a concentric rheostat operating mechanism for the motor and exciter field rheostats should be selected.

If the installation is for 220 v. and not of too large capacity, it is permissible to have a lever switch with fuses located in the circuit ahead of the compensator. If the voltage is above 220 v. the oil circuit breaker is most desirable.

A more elaborate synchronous motor control panel can be had equipped (in addition to the alternating current and direct current ammeter) with power factor indi-

cator, indicating wattmeter, curve drawing wattmeter and curve drawing power factor meter. These additional instruments are justified when best operating results are to be attained. Beyond certain sizes the self-contained starting compensator cannot be obtained, in which case it becomes necessary to use an auto-transformer in connection with two oil circuit breakers operated by tandem mechanisms or a four-pole, double throw oil circuit breaker. The synchronous motor requires direct current for the excitation of its fields. This excitation is usually supplied from a small high speed motor generator set. Occasionally the exciter is driven by means of a belt from a pulley mounted on the compressor shaft. In a plant having more than one synchronous motor it is highly desirable to have several motor generator exciter sets, each set of such capacity as to supply the excitation for the maximum number of synchronous motors on the bus at one time.

Substation and Switchboard Arrangements

It is desirable in an ice plant to guard against complete shut down if possible, due to failure of some piece of apparatus. It is for this reason that duplicate pumps, air compressors, etc., are usually installed. For this same reason, therefore, it is desirable to arrange the transformers in the sub-station so that in case of failure of one unit the other two transformers (assuming three single phase transformers are used) can be connected for open delta operation. This arrangement is conveniently and inexpensively accomplished by the use of six disconnecting switches on both high and low voltage sides of the transformer bank. The lighting for the plant should be taken from a separate transformer, and if possible, this transformer should be connected ahead of the main oil circuit breaker and other major equipment so that it will be possible in an emergency to have light even though the main incoming line oil circuit breaker is open.

Figure 3 shows a typical one-line diagram of connections of a modern electrical installation in an ice plant purchasing primary energy at 13,200 v. The amount of apparatus employed and the connections used depend upon the relative importance of service continuity. In ice and refrigerating plants, as a general rule, an interruption would result, not only in a loss in revenue but a total loss of perishable goods as well as ice in the process of manufacture at the time. Increased insurance against interruptions to service involves the use of more costly and added apparatus. The extent to which it is advisable to carry this expenditure depends primarily upon the nature of the service. No arrangement should be countenanced which in any way subjects the plant force or others to undue hazards. "Safety First" should be the guiding motive of every installation.

In a modern ice plant employing synchronous motors as prime movers it is a general practice to have a switchboard consisting of a main incoming service panel, starting panels equal in number to the synchronous motors installed, an exciter panel for each exciter unit, as many power feeder panels as necessary to take care of the distribution for auxiliary equipment and a feeder panel for the distribution of lighting circuits. The equipment on the incoming line panel varies on account of the requirements of different power companies.

It has been the author's practice to recommend incoming line equipment consisting of a suitable oil circuit breaker with overload relay trip, a voltmeter, an ammeter, a curve drawing wattmeter, necessary current and potential transformers and sometimes a watthour meter with demand meter. Synchronous motor panels and exciter panels of the general design recommended have been described earlier in this paper. Feeder panels are usually equipped with lever switches with enclosed fuses for low voltage circuits or oil circuit breakers with overload trip on circuits above 220 v.

In the opinion of the author the installation of air break disconnecting switches between the bus and all oil circuit breakers is justified as a safeguard against accident to employes while making adjustments and repairs and also to prevent a complete interruption of service

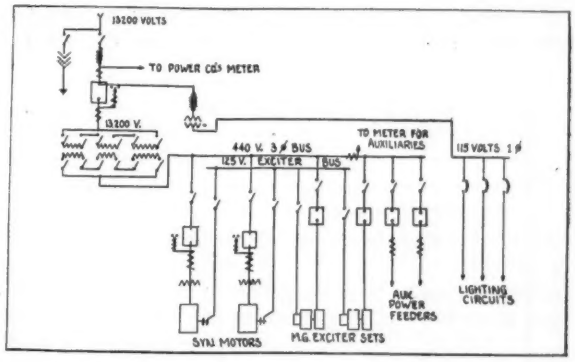


FIG. 3. TYPICAL CONNECTIONS OF A MODERN ELECTRICAL INSTALLATION IN AN ICE PLANT

because of the failure of one oil circuit breaker connected to the bus. A feature of considerable value in connection with synchronous motor driven plants is the use of an electrical interlocking scheme between the synchronous motor and the exciter to protect the synchronous motor field against burn out should the circuit breaker on the synchronous motor open, and also to prevent burn out of the stator winding of the sychronous motor should the exciter become disconnected for some reason.

In conclusion the author would briefly say that all auxiliary equipment, such as air compressors, water circulating pumps, brine pumps, core sucking pumps, dehydrator pumps, agitators, ice elevators, cranes, etc., are invariably driven by motors which are usually of the squirrel-cage type, with the possible exception of motors on the crane; these should be of the slip ring variable speed type.

Cooling-Water Supply Important in Refrigeration Work

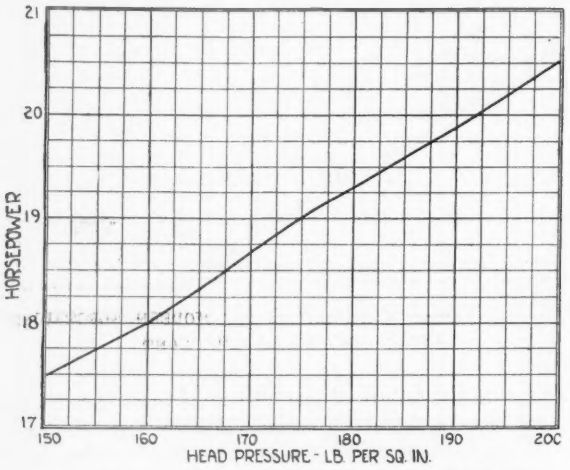
By A. W. Farrall*

FROM the power standpoint, the economical operation of a compression refrigeration machine demands that the condenser pressure or, as commonly stated, the head pressure, be kept as low as possible. Below is shown a curve plotted from results of a test on a 12-T. refrigeration machine. It will be seen that there is a gradual increase

*University of California.

in the power consumption of the machine as the head pressure increases. We find that with a head pressure of 150 lb. per sq. in. the machine required 17.5 hp., while with a head pressure of 200 lb. per sq. in., 20.5 hp. was required, or a saving of 3 hp. at the lower pressure. Assuming that the compressor was operated 10 hr. per day and that power cost 2 cents per kw.-hr., the total saving in the power bill per month of 30 days would be $3 \times 0.746 \times 10 \times 30 \times \$0.02 = \$13.42$. Per year of 12 months the saving would be $12 \times \$13.42$, or \$161.04.

Knowing the effect of a high head pressure, it is desirable to consider the factors which influence this pressure. The temperature to which the ammonia is cooled is by far the most important factor. Ammonia coming from the compressor to the condenser is in vapor form and in order for it to become liquefied in the condenser a certain amount of heat must be taken from it, the high pressure and cooling being the two factors which cause the liquefication of the ammonia vapor. It is a property of ammonia



VARIATION IN POWER REQUIRED TO DRIVE A 12-T. COMPRESSOR AS CONDENSER PRESSURE CHANGES

vapor that the hotter it is the greater must be the pressure in order to cause it to liquefy. This is the same principle which causes water to boil at a higher temperature at sea level than it does on top of a mountain where the pressure is less. In other words, by increasing the pressure the boiling point and the condensing point are raised; by decreasing the temperature the condensing pressure is lowered. Therefore, in order to maintain a low pressure on the high side of the refrigeration machine we must cool the ammonia down as much as possible.

In order to obtain the maximum cooling we must have: First, a good supply of cold water, at least 2 gal. per min. per ton refrigeration, if the water is brought in at a temperature of 70 deg. F., and more water if it is warmer. We are all acquainted with the fact that shutting off the cooling water causes an immediate rise in the condenser pressure.

Second, plenty of condenser surface should be available in order that the heat transfer may take place easily. Oftentimes the adding of more condenser capacity will pay for itself in a short time, due to the fact that a lower condenser pressure will result.

Third, the condenser must be kept free from scale and oil, for these two substances form a film which prevents the proper transfer of heat from the ammonia to the cooling water and thereby decreases the efficiency of the cooling system.

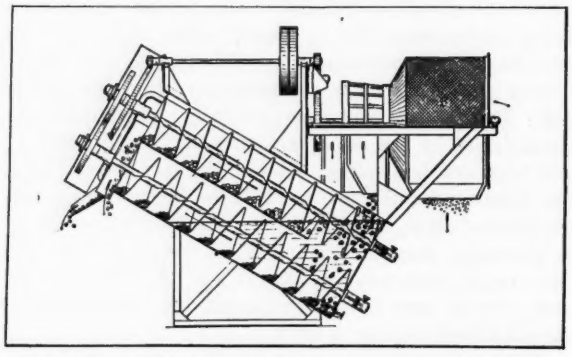
Fourth, use must be made of the counter current principle of cooling, in which the hot vapor enters at the top of the condenser and the cool water enters at the bottom. In this manner a maximum heat transfer is obtained.

Another factor which affects the head pressure is that of the purity of the ammonia. Foreign gases, such as air which may leak into the system, or hydrogen and nitrogen which are formed by the decomposition of the ammonia, may collect in the condenser from time to time and must be discharged through the purge valve. Their presence not only takes up valuable space in the condenser but as they are difficult to liquefy, they cause a higher pressure in the condenser.

Makes Money from Ashes

By Sterling H. Bunnell

ALL OVER the world the high price of coal has forced attention to the possibility of recovering the unburned combustible which is generally present in furnace ashes to the amount of 40 to 50 per cent, except in a few large



COKE SEPARATOR RECLAIMS COMBUSTIBLE FROM ASHES

central station plants having the most modern appliances and expert supervision day and night. In a recent journey in Germany and England the writer was particularly interested in the successful operation of a large number of machines for separating this coke in marketable and usable condition. In this way thousands of dollars worth of fuel are being taken out of ash dumps and savings of 5 to 10 per cent of the fuel purchased by steam plants, glass furnaces, gas works and other coal users is being obtained in hundreds of plants.

By far the larger number of these coke separators have been made and sold by the Benno Schilde Machinery Co. of Berlin. The number of these in use in Germany is well over 300; in England, about 150 and others have been sold even as far away as Australia, New Zealand and Japan. As shown by the illustration, the machine is compact, self-contained and simple. It operates by a small electric motor or gasoline, gas or oil engine and is well within the capability of one unskilled man to operate.

Separating action is on the flotation principle. Ashes are simply shoveled or dumped into the machine and in a few seconds they complete the trip through and are separated and delivered as fines, clinker and coke. The separating apparatus consists of a suitable rotary screen for rejecting large lumps and fines, and a tank containing a

mixture of fine earth and water—that is, a thin mud—in which the coke floats and the clinker sinks, each being removed by a suitable revolving screw conveyor. The whole is as simple as an ash sifter. The ashes may be fed continuously by bucket elevator, as from an existing ash pile, or intermittently from barrows or small cars as brought from the fire-room. The only attention necessary is to replenish the supply of separating liquid from time to time as it works out with the separated coke and clinker.

Coke recovered can, of course, be fired back into the furnaces of the plant from which the ashes came but, as coke usually brings double or triple the price of steam or gas coal, it is usually found profitable to sell the coke to domestic users. The recovered coke is generally equal to gas coke in carbon and ash contents. It may contain 2 or 3 per cent more silica but the difference, if any, is practically imperceptible.

This machine has discovered enormous values hitherto unsuspected in ash dumps accumulated during years of operation. One of these machines at the plant of the Brighton & Hove Gas Co., at Brighton on the south coast of England, has, in a little over one year, worked over the whole dump containing 16,000 T. of salable coke, besides turning the rest of the material into graded coarse and fine ash, all of which has been readily sold for use in concrete construction. The ground occupied by the dump is now clear for additions needed to the gas plant. As the ashes lay in the dump, they were absolutely unsalable at any price and the cost of removal would have amounted to several thousand dollars. The coke separator plant paid for itself in a few months' work and has returned a net profit of $2 a ton of ashes handled, or the sum of $21,000 on the 10,500 T. handled in the first year, besides the value of the cleared land area. The machine is next to be moved to the other end of the plant to clear up another somewhat smaller dump and will then be permanently set up under the ash-removal system of the plant to deal with future ash day by day as produced in the retorts.

Prevention of Air Compressor Heating

DUST DRAWN IN WITH THE AIR MIXES WITH OIL AND CAUSES VALVES TO STICK, RESULTING IN HEATING AND LOSS OF EFFICIENCY. BY R. A. CULTRA

ACCIDENTS occurring recently with compressed air installations seem to indicate some neglect of care on the part of power plant operators. In many well managed compressor plants the cleaning and upkeep of air compressors is so much of a routine duty that unless some extraordinary incident occurs the engineers seldom think of writing their experiences which would aid others to avoid some of the troubles and inconveniences of operation.

Nothing is more detrimental to good air compressor operation than the dirt and dust which is drawn in with the intake air. A great amount of this dust is invisible to the attendant, or if he should observe a small cloud blown against the inlet pipe he is powerless to prevent it from getting into the compressor because the finest possible screen in the inlet line will not catch all the dust and at the same time admit air. With a single stage compressor, the inlet supply is often taken through a tail pipe which is equipped with a strainer and which is attached to the piston and extends through the cylinder head.

Air is taken from the room and in many cases windows are left partially open. Dust, which arises from hurried sweeping of floors around the compressor, is drawn in at the suction and is mixed with oil in the cylinder so that it becomes a pasty carbonized mass which sticks to any parts it happens to strike.

In Fig. 1 is a cross-sectional view of such an air piston. B is the inlet tail pipe and R is the piston rod. The piston in its travel in the direction of the arrow D, takes air through the tail pipe B, into the hollow piston and to the valve ports C, escaping under the ring valve disk V, past the outside edges and the port hole E, in the follower plate, to the cylinder. The follower plate acts as a guide for and holds the ring disk V, in position. On the other side of the piston the air, which is under pressure and is being discharged from the cylinder, has automatically closed the valve ring V. The air escapes through the discharge valve M shown in Fig. 3. In Fig. 2 is an end view of the piston with the tail pipe removed. E are the port holes in the follower plate and Y is the disk or valve ring in position.

Referring to Fig. 1, dust plugs up the passages in the piston, gums up the valve rings on the follower guide and

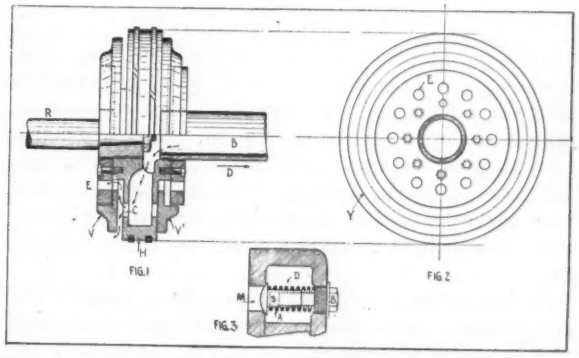


FIG. 1. SECTION THROUGH HOLLOW PISTON TYPE OF AIR COMPRESSOR

FIG. 2. END VIEW OF THE HOLLOW TYPE OF PISTON

FIG. 3. DISCHARGE VALVE USED WITH HOLLOW PISTON TYPE OF AIR COMPRESSOR

causes the ring to stick; or, if bits of waste or sawdust happen to get under the valve ring it will not seat properly and the air will escape back into the tail pipe, causing the piston to leap forward on its return stroke and then the relief valve on the steam cylinder will open. As that side of the air piston is unloaded on this stroke, there is nothing to work against but the compression in the steam cylinder and the governor cannot check the steam admission in time to prevent the piston from leaping. The expansion of unexpelled air in the air cylinder against the piston adds to the pressure of the steam as it is admitted and sends both pistons back against the steam compression, running it up high enough to open the steam relief valve on that end of the steam cylinder.

If there were no flywheels and connecting rods to help check the momentum in such cases, the machine would be wrecked. As it is, if the obstruction blows through under the ring valve on the next stroke, allowing the valve to close tightly on the next return stroke, the compressor will continue to operate but if the obstruction remains, the next return stroke leap will be at a greater velocity than the first one and this will be held in check, not by the compression of steam in the steam cylinder but by the aid of the momentum of the flywheels which are just coming up to the dead center and they will stop there.

Air Pressure Must Be Maintained

Then occurs the trouble encountered of restarting the compressor while the tank pressure drops rapidly. If the air pressure is used for oil heated furnaces, the reduced pressure will cause trouble with the oil heating system also. Dust and other obstructions which are allowed to pack in the hollow piston will finally go through the valve and on to the discharge valve M and will stick on the

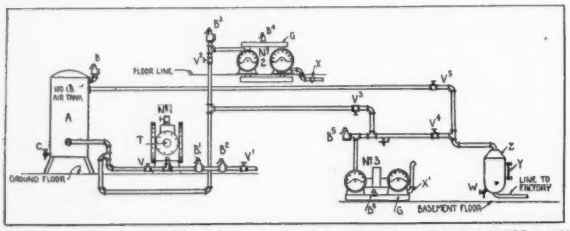


FIG. 4. PIPING ARRANGEMENT FOR A PLANT CONSISTING OF THREE COMPRESSORS

spring as at D, preventing the spring from being compressed enough to allow full valve port opening for the free passage of air through the valve seat. This causes wire-drawing of the air, increased velocity, increased friction and heating of the metal parts of the discharge chamber. This is caused by the discharge valve sticking partly shut while the inlet piston valves may be working freely though handicapped by being gummed up with carbonized dirt.

If the discharge valve, which is hollow, sticks in the partly closed position, there may be dirt and oil collected in the bottom of the part S.

In this condition, with the valves stuck partly closed, there are indications of excessive heating at the cylinder heads and also there will be a sluggish, laboring movement of the compressor while the gage shows that the air pressure is not being kept up to the mark.

Effect of Sticking Discharge Valves

If the discharge valves or a few of them should be sticking open from being dirty and heavily corroded, the air passes back and forth through the valve seat, thus increasing the heating effect. If this same condition exists on both ends of the cylinder, there will be required an increase of compressor speed to make up the loss of pressure in the tank. The compressor may run in this condition for a few days or a week before any serious damage is done. The warning is the constantly increasing heat of the discharge valve chambers and pipe line to the tank and the increase in speed.

Carbonized oil and dirt is of a character that does not burn or ignite quickly when there is considerable oil present; but dry dust without oil will ignite more quickly and burn slowly, causing the discharge pipe to become a dull red. When this happened on a locomotive type air pump, I slapped a few handfuls of water over the strainer pipe and the discharge pipe instantly cooled off. This will check the combustion which is slowly commencing in the discharge line.

If this were not done, the slow burning carbon in the discharge pipe would follow along the pipe until it found some oil, creating a gas and an explosion would follow. The flash point of the oil may not be more than 200 deg. F. and if some grades of kerosene are used for cleaning the flash point would be as low as 150 deg. F.

In some places dry coal dust may be drawn into the compressor and this dust is explosive when a high temperature is reached; if the discharge pipe gets hot, an atomized spray of water or a shot of steam from a steam hose across the end of the inlet pipe will serve to check the heating long enough to investigate and see that the cooling water has not been shut off or the circulating pump stopped. If the cooling water is stopped and the compressor is not extremely dirty, it will run about an hour at moderate speed before any serious heating occurs. Less time is required if the compressor is running fast and if the circulating pump has stopped. It will in most cases be safer to stop the compressor and start the circulating pump than to take chances by leaving the compressor run without any cooling water.

Care must be exercised in using an atomizing spray for cooling a hot discharge pipe because if any great quantity of water gets into the air cylinder, the clearance being small, the head could easily be knocked out. Hence a little steam entering at atmospheric pressure is frequently better. The steam is condensed into water as it strikes the inside surfaces of the cylinder, is distributed over all parts, mixes with and causes the oil to become more or less emulsified, which aids in cooling. In a two-stage compressor, the low pressure air cylinder does not get as warm as the high pressure air cylinder, as it pumps air into the air receiver against only 20 to 30 lb., at which pressure it enters the inlet (suction) pipe to the high pressure cylinder, which discharges the air into the air tank at 100 lb. pressure or more.

If the spray water or steam which is turned into the air inlet pipe is discharged from the low pressure air cylinder into the cooling receiver, it is condensed and the water will be drained out at the pocket of the receiver through the trap and not carried into the high pressure air cylinder except in the form of humidified air. This will require more spraying at the low pressure inlet pipe in order to have sufficiently humid air enter the high pressure cylinder to cool the discharge pipe and check the combustion of carbon.

Permanent Spray Connection Can Be Made

Provision can be made for such an emergency by having a small spraying quill and a ⅛-in. valve connected to the suction inlet of the high pressure air cylinder and a few shots of water can be forced in when necessary with a hand pump. In well cared for machines this is seldom needed. We make it a point to clean the valves of our compressors after about 2 mo. service; or one every month with one or two machines idle each month, as the two smaller two-stage compressors are used at the same time

to do the same work as the large single-stage compressor. Compressor No. 1 in Fig. 4 discharges through the stop valve V, to the air pressure tank A. The moisture and heavy gas have room to settle at the bottom and are blown out through a trap or blowoff valve, C, while the lighter gas rises to the top and safety valve B, being at the extreme top of the tank, if allowed to blow off, which it does several times a day. All the lighter gas which under proper conditions would ignite and cause explosions, is thus gotten rid of.

On compressor No. 1, it is seen that there are two 3-in. safety valves, B^1 and B^2, with no obstruction between them and the compressor, so no over pressure can be put on the cylinder or pipe line in case of sudden stoppage of the flow of air to the tank. Valve V^1 is an open vent pipe used to unload the cylinder when cleaning the piston or discharge valves.

Compressor No. 2 is a two-stage machine driven by a cross-compound engine. The air is discharged from the low pressure air cylinder to the air receiver, G, from which it enters the high pressure air cylinder and is discharged through the stop valve, V^2. B^3 is a safety valve on the discharge pipe and B^4 is a safety valve on the air receiver which will open if the suction valves on the high pressure air cylinder should leak and so give warning of the valve becoming corroded. X is the strainer on the air inlet pipe with an open ¼-in. nipple at the bottom. Through this nipple on the strainer is injected a solution of soapsuds to prevent heating when it is not convenient to stop the compressor immediately.

Compressor No. 3 is another two-stage, compound steam-driven unit, which has the air cooling receiver set in the base frame and the steam receiver is above the base between the two steam cylinders. X^1 is the strainer on the air inlet pipe and B^5 is the safety valve on the discharge pipe. B^6 is the safety valve on the air receiver, so if the safety valves are in proper working condition there is no possibility of getting an over pressure on the receiver or discharge pipe lines.

Separator Placed in Low Point of Line

At the lowest point in the pipe line is placed a separator Z which contains suitable baffles to collect the moisture compressed in the air, leakage through the coolers and also the water or soapsuds which may have been used. Piping is arranged so that there are two pipe lines through the power house and either line can be used as desired. The compressors discharge to the storage tank, which discharges to the lines through the factory. In case of accident to the tank, or when inspection is being made and only a small quantity of air is desired, we can run compressor No. 3 discharging directly into the air pipe lines. If needed, we can connect a portable storage tank to the system near the point where the air is being used. This will keep an even pressure and prevent accident to the pipe lines.

Some erectors make the mistake of setting the compressor so close to other machines or to wall of compressor room, that machines have to be removed or the building torn away, in order to get out the piston and rod. The foundation plan shows how much room is required for removal of piston and piston rod. Care in this will greatly facilitate maintenance.

Air Compressor Capacities and Pressures

AIR COMPRESSORS are rated, as stated by the Compressed Air Society, in terms of piston displacement in cubic feet per minute. This should not be taken to mean the actual capacity of the compressor, or as the actual amount of air compressed and delivered. The discharge pressure, the number of stages of compression and the altitude at which the compressor is to work have a direct effect on the capacity as compared to the displacement.

Pressure for which air compressors are rated is the discharge gage pressure in pounds per square inch. Unless otherwise specified, the inlet or atmospheric pressure is assumed to be 14.7 lb. per sq. in. absolute. Absolute pressure, gage pressure plus the atmospheric pressure, is necessary in compressed air calculations but is never given in trade catalogs.

In making calculations to determine the size of compressor required to furnish air to a given number of tools the figures should be based on the actual capacity of the compressor, which can be obtained direct from the manufacturer. Where large capacities are required, or where an uninterrupted supply of air is essential, the compressor plant should be divided into two or more separate units so that if there should be an accident the supply of air would not be entirely stopped. For this reason it is advisable to use care in the selection of the size of unit, depending principally upon the total demand for air.

There can be no exact dividing line in the range of capacities and pressures to determine where single-stage compression should stop and two-stage compression should begin. There must necessarily be some overlapping due to different conditions. For gage pressures below and up to 60 lb. per sq. in. single-stage compression should be employed. Whether to use single-stage or two-stage compression for pressure between 60 and 100 lb. per sq. in. will depend largely on the capacity required, the cost of the driving power, the altitude at which the machine is to work and whether it is to be a permanent installation.

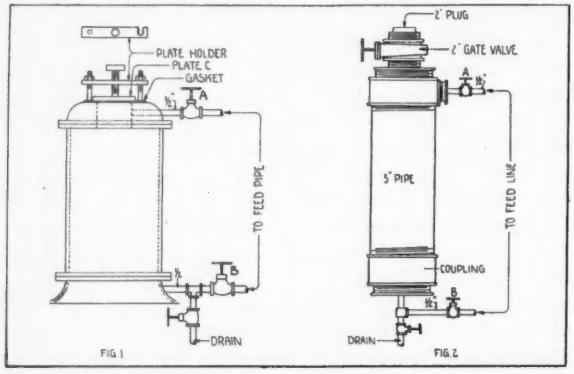
There is no doubt but that multi-stage compression is more economical for gage pressures over 60 lb. per sq. in. though single-stage compressors of less than 350 cu. ft. per min. displacement are to be recommended as satisfactory for pressures as high as 110 lb. per sq. in. It is generally recognized that multi-stage compression should be used for permanent installations for pressures of 100 lb. or more with displacements of 300 cu. ft. per min. or more. Discharge gage pressures of 100 to 125 lb. per sq. in. are considered standard for two-stage compression.

Single-stage sea level compressors compressing to 100 lb. per sq. in. should not have a stroke greater than 14 in. This is because of the difficulty of cooling the air and compressor parts due to the heat of compression. This is important at high altitudes.

While the capacities and pressures given above are to be recommended, there are, of course, conditions which sometimes require a deviation from these values to secure the best results. The operation of these special types of compressors is commercially successful both from a practical point of view and an engineering point of view. For example, the straight-line oil, gas and gasoline-engine-driven compressors must have a longer stroke and greater speed on account of the characteristics of the driving unit.

Soda Ash as a Boiler Compound

I HAVE USED soda ash as a boiler compound for many years with good results as my boilers are practically clear of scale. At the last inspection of the boilers by the boiler inspector he inquired how I was able to keep the boilers in the condition they are with soda ash alone.



FIGS. 1 AND 2. TWO TYPES OF COMPOUND FEEDERS WHICH HAVE BEEN FOUND SUCCESSFUL

I know some engineers and plant owners are against using soda ash as a boiler compound, due to the fact that they are under the impression that it ruins rod and stem packing on the engine, etc. Also eats the gaskets in steam line flanges and unions.

I have often been asked by engineers and others how I use the soda ash and what type of feeder I use.

In the first place, if good results are desired with soda ash, good judgment must be used; by this I mean that enough must be supplied each day the boiler or boilers are in service to keep them clear of scale. This easily can be found by feeding a certain amount of soda ash to the boiler each day from one cleaning time to the next. Then by observing the condition of the boiler at the next cleaning time, increasing or decreasing the amount of soda ash used until the correct amount is found to just keep the boiler clear of scale.

My way of using soda ash is as follows: After each cleaning of the boiler and when filled with water again, I thoroughly dissolve about 6 lb. of soda ash in a pail of water, then empty this into the boiler through the top manhole.

During the time the boiler is in operation, I feed about 12 lb. of soda ash into each boiler per week, boilers being of 150 hp. capacity, which amount I find keeps the boilers clear of scale. Figure 1 shows the type of feeder I use, which can be connected to a vertical or horizontal feed pipe, as the case may require. Before placing the soda ash in the feeder, it is first thoroughly dissolved in water. Plate C is then removed from feeder and soda ash poured in. After the plate is replaced, valve A is opened wide while valve B is just cracked. This allows a little of the soda ash solution to enter the boiler at each stroke of the feed pump or at each dumping of the feed trap.

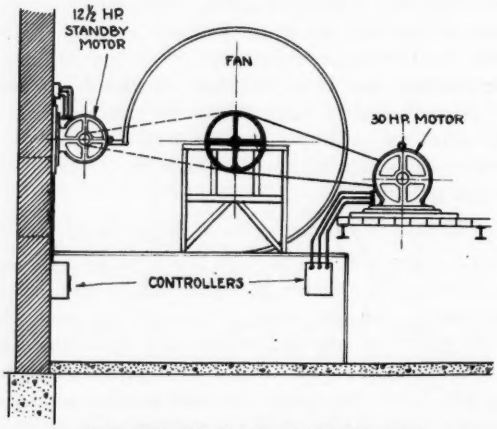
I also have used feeders of the type as shown in Fig. 2, which is a homemade type made out of a 5-in. nipple about 18 in. long with a coupling and bushing reduced to ½ in. at the bottom. At the top there is 5 by 5 by 2-in. tee where the side outlet is reduced to ½ in., while the top is reduced to 2-in. When filling this feeder the 2-in. plug is removed and gate valve opened and the soda ash poured into the feeder in a liquid form.

The 2-in. plug is screwed into the valve for the reason that the gate valve is liable to leak.

Milwaukee, Wis. H. A. JAHNKE.

Spare Motor to Drive Fan

IN OUR plant we have a 12-ft. fan which is used for heating a factory in cold weather. When this fan was installed there was an engine provided to drive it and this



ARRANGEMENT OF SPARE FAN MOTOR

arrangement prevailed for many years until someone thought that a motor would be better adapted for the work and its use would save running the fan engine when the larger engine units were in service.

To this end a motor was purchased and mounted on the platform as shown in the accompanying sketch. The controller for this motor is made up of 5 contactors similar to small circuit breakers. In operating the motor, it is customary to judge the speed of the fan by the number of notches or contactors engaged. It is hardly ever necessary to run more than three in after the rooms are warmed up.

The engine was seldom operated after the motor was installed unless there was need for repairing the motor and it was desired to remove the engine if there would be

no danger of the motor failing. If such a contingency came up during freezing weather it would prove serious for the sprinkler system as well as other water pipes, hence the following plan was decided upon.

Readings were taken to see how much power was consumed at the different points on the controller. It was found that three notches required 13 hp., four notches, 17 hp. and five, 24 hp. Since three notches would keep the factory from freezing and warm most of the time in winter and since there were two slow speed motors available that had been taken down from driving machines of 12½ hp., it was decided to use one of them. It was therefore hung on the wall of the fan room as shown. After being connected up, it was operated for two days at full load and it furnished ample heat for the time at which it was run. It also proved that should the large motor need repairs at any time which would tie it up for an indefinite period the small motor would provide heat enough for any weather by running it all of the time. After everything had been tried out, the belt was taken off and rolled up with the motor and the whole wrapped in black oil cloth so that it would be ready whenever needed.

East Dedham, Mass. G. H. KIMBALL.

Taking Chances

STATIONARY engineers are supposed to be among the most careful and painstaking of mechanics. They are usually held accountable for loss of life, and are also responsible to their employers for damage to property, caused by negligence, or inattention to the machinery of which they are in charge. There are men who would not cross a strange pasture after dark without a lantern but who will assume charge of a strange plant with only the most cursory examination. One cannot know the condition of a plant, especially if it is standing idle, with that sort of an inspection. A man will go in a strange plant, say, on a Monday morning (I have done it myself) to start up, taking the chance that everything is in order. The engineer preceding you may have been disgruntled or may have left under a cloud, so to speak, and may not have taken much pains to leave the plant in shape for his successor. If the old engineer should chance to be there to show you over the plant, he might not take the trouble to point out all the imperfections.

I once took charge of a plant in a hospital in New York City. I was shown two bags on the front sheet of one boiler but nothing was said about the guards and bolts being burned off the handhole plates of the other three boilers. In another case the engineer of an apartment house had been discharged. I started there on a bitter cold day in February. The return trap was broken and the returns were going to the sewer. The pipe from the return tank was under the floor and the cock was situated on the ground in front of the cleanout door. The last thing the engineer did before leaving was to close the cock and cover it with ashes. I was 3 hr. in locating the trouble and getting the radiators clear of water in order to heat the house.

Carelessness of some contractors, or their men, is sometimes stupendous. I once took charge of a new plant for a railway in Maine. We had been running about a week, carrying 115 lb. of steam, when a leak developed in a screwed joint, in an 8-in. steam line. The following Sunday, we opened a flange union adjacent to the leak and the pipe fell apart at the leaky joint. The thread had entered the fitting only a fraction of a turn. I was in charge of a new plant in a large loft building in New York. A leak developed in the Vanstone joint of a 12-in. pipe carrying 150 lb. pressure. Upon removing the magnesia covering from the flange we found that three bolts had been left out of the joint and the joint covered.

It seems to me that such cases amount to criminal carelessness. In the event of a serious accident, investigation might make it appear that the engineer in charge had the bolts out and possibly he would lose his certificate as well as his job. A friend of mine, starting up a strange plant for the first time, lost a nut and ball off the governor; it happened to drop when the engine had made but a few revolutions, otherwise there would have been a chance for someone to get hurt.

In a 5000-hp. plant a set of rules was posted governing the watch engineers. Rule No. 1 required that engineers should report for duty 15 min. before relieving time, to make an inspection before relieving the watch. Half of that time would be spent in changing clothes, then it was necessary to inspect seven Corliss engines, seven generators, 11 water-tube boilers and race through 200 ft. of cellar to inspect the condensers and pumps, before an engineer could sign his relief's O. K.

We are constantly reading in the daily papers, of boiler and flywheel explosions, bursting steam pipes and other accidents, the result of which is nearly always loss of life and destruction of property. An old adage is, "eternal vigilance is the price of safety."

Utica, N. Y. M. M. BROWN.

Repairing a Crosshead

WHILE A wristpin will stand a great deal of abuse, there is a limit and this in one case resulted in the boxes freezing to the pin, causing the key in the pin and crosshead to enlarge the keyway and the pin to turn.

This made it impossible to hold the pin after a new keyway and key was provided. The punch marks on the piston rod, check nut and neck of the crosshead were verified with the tram. The connecting rod was removed and lock nut slackened back. The back cylinder head was then taken off and a piece of 3 by 4 joist put across the cylinder studs. A bar was used to turn the piston rod out of the crosshead by using the joist as a fulcrum and the end put into the counterbored holes in the follower plate.

The top shoe was then taken from the crosshead and a short piece of pipe put through the crosshead and a rope sling put on each end of the pipe and hooked onto the chain falls. By steadying the crosshead and gently pulling the top away from the frame while lifting on the falls the crosshead was easily taken out of the guides.

Next, the bottom shoe was taken off the crosshead and then it was put on the boring mill. Both eyes for the pin were bored out, keeping the original taper. An open hearth steel forging was obtained and a new wristpin turned up and carefully ground into the eyes of the crosshead.

The distance between the bosses on the inside of the crosshead was calipered and this distance transferred to outside calipers. Then the distance over the outside of the boxes was measured and compared with the inside

measurement of the crosshead. As there was a difference of $\frac{1}{16}$ in., a knock would develop, due to side slap of the boxes on the wrist pin.

These boxes were mounted in a chuck and $\frac{1}{8}$ in. squared off. A piece of sheet brass was secured to the boxes with counter sunk head machine screws. The brass plate was then faced off so as to leave a clearance of 1/64 in. inside of the bosses on the inside of the crosshead.

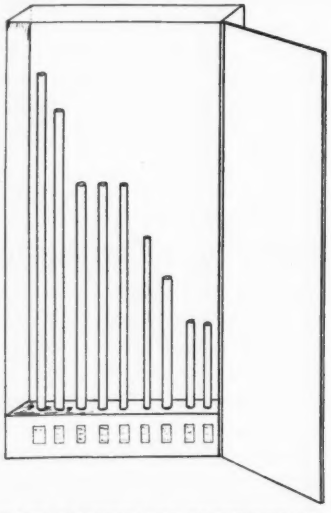
The piston rod was screwed into the crosshead with the bar, until the correct tram distance was obtained, when the lock nut was securely tightened.

On starting the engine, it ran quietly and without heating.

Methuen, Mass. P. E. MERRIAM.

Closet and Rack For Storing Gage Glasses

PROBABLY ONE of the most touchy articles which the average plant engineer has to handle is the gage glass, not only because they are always subject to breakage but also because breakage will be materially increased if the glasses are carelessly handled, that is allowed to become nicked or scratched in handling. In view of their fragile nature,



GAGE GLASSES ARE PROTECTED BY STORAGE IN A SPECIAL CASE

the place to store spare or reserve gage glasses is not among tools in a chest or among pipe, but in a place just set apart for the purpose.

In our plant we have made up a little cabinet, somewhat along the lines as indicated in the accompanying sketch, where we store our spare glasses, away from dirt and dust, and with the minimum chance that they will get scratched or nicked. We also store the glasses already cut to size, each rack being tagged with the name of the gage for which that certain glass is cut. Often when a gage glass blows out it is important that the replacement be made promptly and it is much better to utilize spare time before the break occurs in cutting the glass to size so that it will be ready in the emergency, than that there should be a hustle in getting the glass cut under stress conditions. The following out of this scheme of a store-cabinet for spare glasses is recommended as being worth while, based on our experience with it. M. A. S.

Oil Fouled Commutator

RECENTLY I received a phone call from a neighbor asking me to come over and locate the trouble on a 50-kw. d. c. generator. When I arrived on the scene he informed me, in answer to my inquiry, that the unit would not pick up its load. I told him to start up but he told me it was no use, he had tried several times with no results. I finally prevailed upon him, however; he started up and the machine started to generate almost as soon as it was up to speed. This had been going on for some time, he told me, the machine failing to start after a prolonged shut-down.

After a close examination I was able to locate the trouble; it was nothing more than an occasional drop of oil on the commutator from an overhead bearing. When the machine was idle these drops would form a film over the commutator which would prevent the brushes making contact. After the machine had been running a few minutes the brushes would wipe off the film and make contact, when it would pick up the load. A few minutes' work with a piece of sandpaper cleaned up the commutator and when a catch pan had been hung under the offending bearing the machine was able to run without further difficulty.

Toronto, Ont. JAMES E. NOBLE.

Mistakes in Textbooks

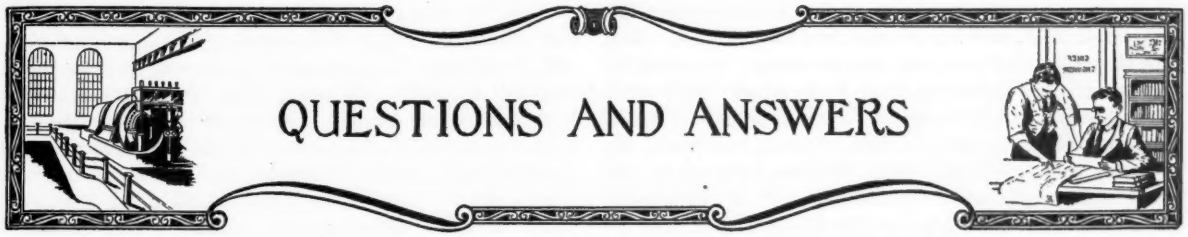
IN THE Aug. 1 issue, W. F. Schaphorst discusses mistakes in textbooks and suggests that authors and publishers be informed of errors appearing in their books. No doubt, authors and publishers would be glad to receive notice of errors and suggestions for the improvement of their books but the difficulty seems to be in an inherent diffidence possessing engineers in general, a diffidence that has excited much comment and which has, in the legal mind, branded the engineer a kind of genius but one who need not be taken seriously. If the engineer were made to feel that he is performing a real service he would probably come out of his shell.

As an illustration of how errors may persist and how diffidence, inertia, or whatever it may be called, prevents action, about 20 yr. ago I bought a copy of text on steam power plants. Accompanying the matter relating to siphon condensers was an illustration, a dimension line indicating 34 ft. as the distance from the center of the water-injection pipe to the lower end of the tail-pipe which is, of course, several feet under the surface of the water in the hotwell. The text, however, gives a correct description of such an installation as 34 ft. to the surface of the water in the hotwell. This being the first edition of the book, which was dated 1902, I merely thought that the second edition would show the error corrected.

In 1905 came the second edition and in 1912 the third edition with the error carried on. I took no action for reasons that would be hard to explain but should there be another edition of the book and with the same error, I will certainly write the publisher.

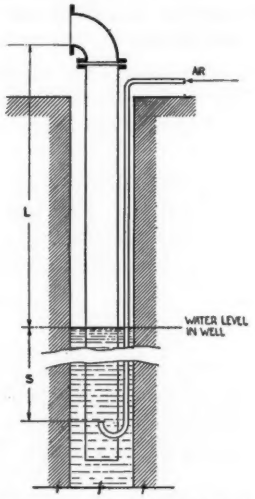
Kansas City, Mo. C. O. SANDSTROM.

IF YOU run an excuse factory, sell out and take up a line that pays. One-half the gray matter expended on the generation of an excuse would have prevented the error every time.



Air Lift Design

WE CONTEMPLATE putting in an air lift installation to pump water from a well on our property. This is a 10-in. well 500-ft. deep and the lift is about 60 ft. Air is to be supplied by an 8 by 8-in. double acting compressor running at 200 r.p.m. How much water can be pumped at



TYPICAL AIR LIFT INSTALLATION

the maximum efficiency of the installation; what size water pipe should be used and what will be the power requirements? L. W. G.

A. For maximum efficiency with a lift of 60 ft., experience has shown that the submergence should be about 2⅔ times the lift or about 160 ft. Maximum capacity may, on the other hand, be obtained with a submergence of about 4 times the lift or about 240 ft., but the efficiency will be materially reduced. With a submergence of 160 ft. the volume of air required per gallon of water delivered may be found from the equation:

$$v = L \div [\log (S + 34) \div 34 \times 225 - 0.1L]$$

Where v is the cubic feet of air required per gallon of water delivered, L is the lift in feet and s, the submergence in feet. Substituting the values given:

$$v = 60 \div [\log (160 + 34) \div 34 \times 225 - (0.1 \times 60)]$$
$$= 60 \div [\log (194 \div 34) \times (225 - 6)]$$
$$= 60 \div (0.756 \times 219)$$
$$= 0.361 \text{ cu. ft. per gal.}$$

Inasmuch as the volumetric displacement of the pump is:

$$V = 0.7854 \times 8^2 \times 8 \times 2 \times 200 \div 1728$$
$$= 93 \text{ cu. ft. per min.}$$

the capacity of the well will be:

$$Q = 93 \div 0.361 = 257 \text{ g.p.m.}$$

For a flow of 257 g.p.m., experience has shown that about a 6-in. pipe would be the most economical size. The size air line to correspond with this size water pipe will be about 2-in., nominal diameter.

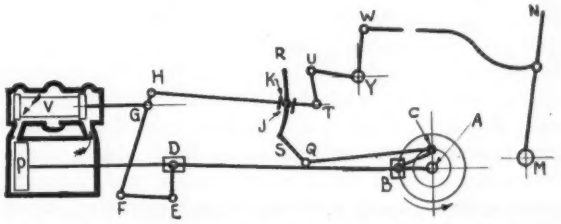
With this submergence the air pressure required will be about 80 lb. gage and the power required, as determined from actual practice, will be about 0.19 hp. per cu. ft. of free air per min. As, has been found, 93 cu. ft. per min. is required, the total power consumption will be $93 \times 0.19 = 17.7$ hp.

These figures are based on the assumption that the lift referred to is the actual running lift or that, if the figure given refers to the static lift, the rate of infiltration of water into the shaft is sufficient to the operating level at but little below the static level. If this is not the case, i. e., if, while the well is in operation, the water level drops enough to increase the lift an appreciable amount, the submergence must be increased. This, of course, will mean greater air pressure and correspondingly increased power requirements.

Length of Eccentric Rod on a Walschaert Valve Gear

WILL YOU kindly inform me how to find the length of the eccentric arm on a Walschaert valve gear. The original rod has been broken and no way of measuring it for a new one. J. O. R.

A. There are three distinct parts of a Walschaert gear, the crank system, the valve and the reversing mechanism. Obviously they bear a certain definite relation to each



DIAGRAMMATIC LAYOUT OF A WALSCHAERT VALVE GEAR

other. If one of the links connecting these three parts is missing its correct length may be found by setting the three parts in corresponding positions and measuring the distance between the two points that the missing link should connect.

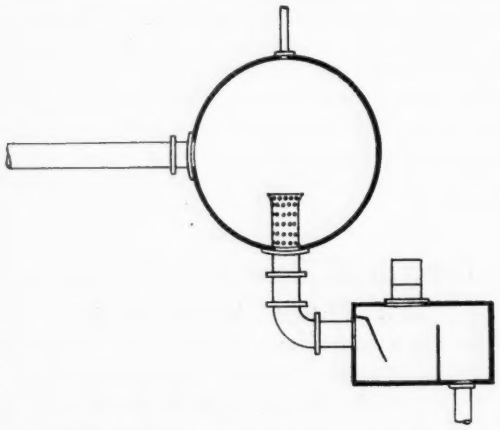
Specifically, set the crank, B, at say, the head end dead center so that the eccentric pin, C, is vertically in line with the crankshaft, A. Then set the reversing mechanism in the mid-gear position. In this position the block, J, on the valve link, H-T, is directly in line with the pivot, K, about which the yoke, S-R, oscillates. This yoke, being free at Q due to the missing eccentric link, Q-C, is free to move about K as a center.

With the yoke in the position corresponding to the crank in the position shown, the center of curvature should

lie on the point, H, the center of the pin connecting the radius rod, H-T, and the lap and lead lever, H-S-F. The correct position of the yoke may be found by carefully tramming equal distances from H to either end of the yoke. The points at the ends of the yoke selected for this measurement must be equi-distant from the point, K, about which it oscillates. With the yoke clamped in the position thus found, the distance, Q-C, from the pin on the reversing link or yoke to the eccentric pin may be measured to determine the correct length of the eccentric rod.

Metering the Blowoff

WHILE THE method mentioned by G. W. G. on page 772 of the July 15 issue for measuring the blowoff from a boiler might be accurate enough for a small plant, for an installation of 8000 hp. it seems to me it would be well



SURGE TANK AND V-NOTCH METER ARRANGEMENT FOR BLOWOFF SERVICE

for him to install something more efficient. An arrangement which I understand has been used successfully in a number of the larger central stations is a V-notch meter arrangement somewhat as shown in the accompanying sketch. The blowdown discharges into a steel surge tank in the bottom of which is a vertical perforated pipe which discharges the blowdown liquor in a fairly steady stream down into a V-notch meter, where it is metered by passing it over a notch, using a standard chart recording instrument. The V-notch type of meter is well suited for this work because it is accurate at low flows as well as at high flows; it is easily accessible for cleaning and, used in conjunction with the surge tank shown, it provides for a sufficient smoothing out of the flow to get a fairly accurate and reliable record. Both meter and receiving tank are of course vented to atmosphere, with generous sized connections. Both tanks should also be fitted with clean-out doors or sluices to flush out accumulation of mud and silt, especially if the water is of poor quality. M. A. S.

Air Chamber Capacity for Pump

IN REPLY to Mr. Riecke's question on page 772 of the July 15 issue, it may be said that unless the suction pipe is unusually long, either vertically or horizontally, or both, there is little need of an air chamber.

One defect can be noted, the suction is the same diameter as the discharge. When starting the pump acts rapidly, as is frequently the case in elevator service, the pump starting at capacity delivery, it is of no inconsiderable benefit to reduce friction as much as possible in the suction pipe, especially where the lift is high, and the distance from the point of supply great. The only way to reduce the friction in the suction pipe is by having it larger than the delivery pipe. An air chamber of ample capacity can be of considerable benefit on the discharge line in an installation of this nature, where the discharge line may be long, and the quick checking of the water supply in operating the elevator valves, requires all the cushioning possible by the use of an air chamber, or relief valve or both to minimize the shock caused by the check.

If there is a check valve on the discharge pipe, the clanking noise may be caused by the movement of the swing flap, or disk holder.

If the pump valve springs are old or defective or loose and the valves are of metal, every time an elevator valve is opened or closed quickly the pump valves are likely to slam.

When enlarging the discharge air chamber, be sure that it is perfectly airtight. Any leak at the top, be it ever so small, will have the effect of completely destroying the utility of the chamber, as a shock absorber.

Toronto, Ont. JAMES E. NOBLE.

REFERRING TO the pump trouble cited by Charles L. Riecke in the July 15 issue, it may be said that he is right in his idea of enlarging the discharge air chamber but his idea of doing away with the chamber on the suction line is wrong.

The air chamber on the discharge side of the pump is too small. The proper size of an air chamber depends on the type of pump, the speed, the length of the discharge pipe and the pressure against which the pump works. For ordinary pumps, moderate pressures and speeds, the cubical contents of the air chamber in the discharge line, should not be less than three times the piston displacement.

For pressures of 100 lb. and up, or for high piston speeds, the capacity should be at least six times the piston displacement.

I would advise that the air chamber in the suction line be allowed to remain in, with a long suction pipe or a pipe with elbows, bends, and valves in it, the resistance to the flow of water through it will be considerable, and a great deal of force will be required to start and stop the water with each stroke of the pump. In some cases the force required is so great that the pressure of the atmosphere is not sufficient to set the column of water in motion quickly enough to fill the pump chamber. This makes the action of the pump imperfect and causes a severe water hammer, when the piston meets the inflowing water.

When properly proportioned and placed, the air chamber in the suction line will take care of the trouble referred to, on the suction side of the job. Usually these chambers are spoken of as vacuum chambers, or as suction air-chambers, because the pressure in them is less than atmospheric.

When the pump is "taking" water, the air in the vacuum chamber expands and forces the water into the pump; at the same time the pressure of the air on the surface of the supply water forces the water, in through the suction pipe to balance the reduced pressure in the vacuum chamber. The vacuum chamber is again partly filled and the air in it is compressed during the discharge stroke of the pump. Thus it acts as a reservoir that receives from the suction pipe a nearly steady supply, which is given up to the pump without jar or shock.

For ordinary cases the size of the vacuum chamber should be about one-half that of the air chamber on the discharge side of the pump, or approximately twice the capacity of the pump cylinder.

It would seem that in Mr. Riecke's case the trouble is that the suction air chamber is too large and the discharge air chamber too small. By changing the sizes, his trouble will cease, assuming, of course, that all else about the whole job is correct.

Both suction and discharge air chambers should be placed in a bend in the pipe and near to the pump. They should also be so placed as to be in line with the flow of water in the pipe. If placed at right angles to the flow their efficiency is impaired. Both chambers should be provided with gage glasses so that the height of the water can be determined at a glance.

Brooklyn, N. Y. CHARLES J. MASON.

Paint for Use in Oil Tanks

IN REPLY to the question by C. B. S. on page 719 of the July 1 issue concerning the use of paint in an oil tank, it may be said that the time required for cleaning and repainting is so expensive compared with the gain in the life of the tank that many oil storage tanks in the steam plants are not painted on the inside but are instead frequently galvanized. Though tanks are often painted inside when new, they seldom receive the second coat except perhaps on the outside for the sake of appearance. The paint on the inside does not last many years without peeling off in spots because of oil and water working under the paint. This flake paint causes trouble in the choking up of all the sight feed valves, feed lines and oil holes.

The oil itself will preserve the metal if the water is drawn out every day or so and not allowed to accumulate in the bottom for any length of time. If it does, it will be pumped with the oil around through the oiling system and the oil will become emulsified and may choke up the oil feed and return pipe lines so that frequent cleaning of all pipes and the tank itself will be required and, what is of greater importance greatly over-heated bearings are likely to result. The drawing off of the water each day brings the oil in contact with the bottom of the tank and tends to preserve it except that drops of water remain at the edge of plates and around rivets which may cause some pitting. When the tank is emptied as it should be every two weeks or once a month, scraped clean, washed with kerosene or soda, as may be required to remove the sludge which will collect between the oil and water, and dirt, there is little need of it being painted on the inside.

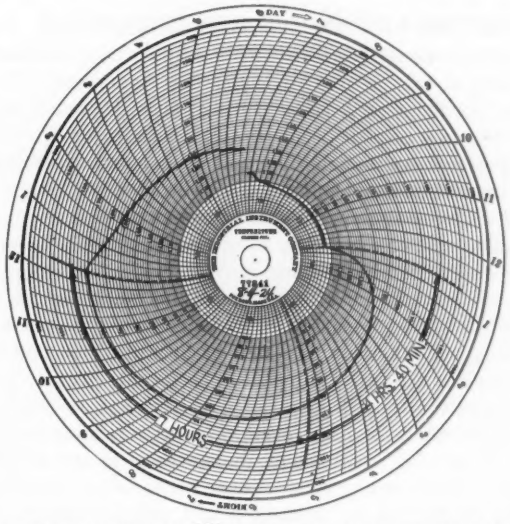
This procedure has to be gone through at frequent intervals in all large steam plants whether the tank is painted or not. If, however, it is desired to paint the tank, any good paint dealer can furnish a paint for boiler metal which can be applied with either a hand or air brush. Several coats must be applied before it is in condition to use. If the paint is put on too thin, it will run down from the top and leave excessive deposits on the bottom and it is under the edge of these thick deposits, when they commence to peel off, that the water causes pitting, hence the deposits must be scraped out each time the tank is painted. The paint must be thoroughly dry before the tank is put into service or it will gradually become mixed with the lubricating oil.

We used a boiled oil red lead paint for the inside of our elevator tanks but the greases used for lubricating the elevator machines contain so much animal fat, which in turn contains some salt moisture, that it soon destroys the paint in patches where peeling causes erosion and pitting to begin. After they are thoroughly cleaned each year, we give them a new coat of red lead paint.

Cambridge, Mass. R. A. CULTRA.

Heating Service Required for Dry Kiln

IN THE Aug. 15 issue on page 871 there was published a question by myself concerning the amount of heating surface required for a dry kiln for drying paint. Since I



A TEMPERATURE OF 170 DEG. F. IS NOW ATTAINABLE

submitted this question, I have done some overhauling and added some radiation. The company that supplies the paint has also made some changes in the composition of its paints and enamels so that there is now no danger of the paint changing color if subjected to a temperature higher than 160 deg. F. or for a longer period than the old schedule called for.

By rearranging the fittings on the old coil and by changing the supports for the kiln floor we were able to make room for another coil of six 1¼-in. pipe, 32 ft. long under the flooring. The addition of this extra 75 sq. ft. of surface to the original 450 sq. ft. (not 350 as I stated in the question) gives us 525 sq. ft., which enables us to attain a temperature of 166 deg. F. in 4 hr. and 40 min., as shown on the accompanying chart.

So far we have had fine results, the paint coming out dry and hard.

Minneapolis, Minn. FRED S. RUTLEDGE.

EDITORIAL COMMENT

If Winter Comes

According to all the laws of nature winter will soon be upon us. Are you prepared? How about the old heating system? Is it in good working order? How about all those repair items you made a note of last winter? Have they been taken care of? You don't want to have to shut down some day next winter when it's 10 below on account of the failure of some important piece of equipment. Better give the whole system a careful inspection now and put it in first class operating condition; then there will be less likelihood of having to interrupt service next winter.

By the way, have you looked at the coal pile recently? If you are low you still have a chance to lay in a supply but you never can tell how long it will last; there may be a shortage later on and prices may jump.

Sketches and Notes are Important

Many an engineer insists upon keeping the plant under his care so that it presents a pleasing appearance. He is proud of the results he is getting; the CO_2 being high, maintenance costs low and the indicator cards from his engines look as though they had been hand drawn upon the basis of theory alone.

This same engineer, however, cannot or will not make sketches or notes so that they are intelligible to anybody else, or to himself when they are but a few weeks old. If he does make an attempt at making such records his method of filing them for future reference is not at all in keeping with the way in which he operates the plant.

Because a repair job has been performed once, it is no assurance that it will not have to be done again. Further, a change which has been made may not prove satisfactory and it may be advisable to change back to the original scheme. Without a good system of sketches and notes, much work must be duplicated and often details of the greatest importance depend upon the memory of the one man who performed them. Guessing has no place in power plant operation and still, without records, it must be resorted to.

It is a credit to any engineer to have with him in his work or to leave behind him a well kept set of clear, definite and comprehensive sketches and notes of the work, which has been done and work which he believes will improve operation.

Asking Questions

Asking questions for information is an art. Some possess this faculty in greater degree than others and some there are who seem to have it not at all. In the final analysis it all comes down to a question of logic, the ability to differentiate between cause and effect. In asking a question it is obviously of no use to include information or facts in the conditions that have no bearing on the answer and conversely it is highly important that all available facts on conditions influencing the answer be given or understood.

The well ordered, logical thinking man will marshal all his available data, arrange it in a logical manner and then go after the answer. It will be found that where the first two steps have been completed a method of solution usually suggests itself. The successful carrying out of the preliminary steps is truly half the battle. You have to be well primed to ask an answerable question; don't go off half cocked. Fewer foolish questions would be asked if they were thought out in this manner.

On the other hand, don't hastily condemn a question as foolish just because you cannot immediately find an answer or see a cause and effect relation.

Asking, and answering, questions is an art but it is one that can be developed by the application of a little clear thinking. Try it the next time you have a problem to solve.

Keep Everlastingly at It

Maintenance work about a power plant generally means a great amount of hard work, not alone from the viewpoint of physical effort and time but from the viewpoint of study and a perseverance which will not allow any part of the work to be slighted.

Many parts of a big job tend to go easily and often the worker is tempted to slide over them as if they were inconsequential and did not deserve the same degree of attention as other parts of the job. Then there are other parts of the work which are extremely difficult and tedious, again offering the opportunity to the worker to pass over them in as easy a manner as possible, much to the detriment of the successful operation of the equipment.

This attitude may soon become a habit, with the result, that the person who practices it will shirk every job which he undertakes. His motto becomes that of the easiest way and he unconsciously undermines his own character because he will not stick to a job until it has been completed in the best possible manner and better than he had performed the same job or one similar at a previous date.

Probably no better example of perseverance and determination exists that that of Lincoln's early political career. When he first ran for Congress he was badly defeated. He failed in an attempt for an appointment in the U. S. Land Office. He was defeated when a candidate for the U. S. Senate. Twice again he met defeat, once in an effort to become vice-president. Finally, however, he was successful and became one of the country's greatest men. This required perseverance and it won, just as it will in the power plant, or in any other phase of engineering.

In operative and maintenance work it often occurs that the same job must be performed a number of times. Each time it must be done a little better, this being possible because of perseverance in the study of cause and effect and in doing the work in the best possible way. Each time

some advancement is made until finally the difficulty has been overcome. It has become a worth while accomplishment. It has built character and inspired confidence, not only in the individual but also in those with whom he is associated and in those who come to know of his work.

Bring Out the Torches—the Parade Is On

When political orators begin to talk in generalities on subjects which require the detailed study of experts, the result is usually a muddle of misleading half-truths. An excellent illustration of this fact is shown in some of the statements made by representatives of the major political parties in discussing the power problems of the country.

Since the platforms of the major parties contain references to policies which are to be followed in considering the nation's power problems, it is rather interesting to note the use of this sort of campaign material. Governor Bryan, however, made some statements in his speech of acceptance which can hardly go unchallenged. Amidst the red fire and the waving torches, the following gems of fancy were offered the power industry:

"The democratic platform favors the development of our water power. If the water power of Muscle Shoals and in the mountain streams and in the rivers throughout the land were developed it would supply the power to operate all of our factories, all of our industries and all of our means of transportation. It would enable the raw materials of the country to be manufactured where they are produced, thus saving the cost of transportation of the raw product to the factory and the finished product back to the consumer. It would enable industries to spring up where needed most to create business and to supply human needs. If the water power of the nation were developed it would furnish electric current to light and heat the homes of the cities and on the farms, and supply electric power to operate all the machinery necessary for the needs of the farms and for the convenience and comfort of the homes, both rural and city, at a small fraction of the present cost."

If the engineer were to comment on these statements, regardless of party affiliations, he would say: 1. If all the potential water power of the country were developed it would not supply half the power requirements of the applications enumerated. 2. Decentralization of industry is not entirely a matter of power supply. 3. Electric heating is extravagantly wasteful except for certain special applications or where surplus water power is available. 4. Electric service to the farms is not so much a matter of cost of power as it is cost of distribution. 5. Water power does not necessarily mean cheap power. The fixed charges of plant and distribution may cause the power cost to be even higher than for the fuel burning plant.

In making statements of this kind the Democrats hold no monopoly. Campaigners for the other parties are just as prone to play loosely with the facts. For that reason the engineers can render the country a real service by putting aside political affiliations in order to challenge misleading statements which may, if allowed to go unchallenged, build up a misconception in the public mind as to what engineers are doing in the broad field of power development.

Off Duty

In considering our present day sources of power it is strange that the oldest and most widely distributed form of available power is used the least. This is wind power.

The use of wind as a source of power dates back a long way. Long before anybody ever dreamed of a power plant, the winds were used in all parts of the civilized world for propelling ships. On land, windmills came into use early in the history of civilization and in the Netherlands were, and still are, the primary source of power for pumping water. As a general source of power, however, wind never amounted to much and as a competitor of coal, "didn't have a leg to stand on." Today, except for a few applications on the farm, and a rather wide use in political circles in the heated form, however, wind power is all but forgotten.

Our coal supply, however, will not last forever and in countries where coal is scarce they are already beginning to think of using wind power once more. In the United States where we are accustomed to speak in terms of billions of kilowatt hours this may seem like small pickings and we may be inclined to turn up our noses at it. But in this we had better be careful for the wind may not be such an unimportant factor in our power resources as we think. Anybody doubting the power of the wind has probably never experienced a ninety-mile gale at sea or met up with a Kansas cyclone.

In France, in order to relieve the country of its heavy burden of payment for imported coal, engineers are planning extensive windmill plants. Some extremely interesting experiments have been made on the Eiffel tower in Paris to ascertain the best form of windmills to use and the results of these experiments indicate a type of mill radically different from those used in this country.

Our windmills in America are from 8 to 16 ft. across and have 18 or more blades. The new French mills have only two blades *but* these are made much larger, in fact, plans contemplate windmills with two blades revolving in a circle 100 or 130 ft. in diameter. With a 22 mi. wind these windmills will deliver from 200 to 400 hp. With a 13 mi. wind the power delivered will be from 50 to 90 hp.

One of the proposed installations will be on Mt. Ventoux, 5000 ft. above sea level, where a series of 130 ft. mills are to be erected. Constantin, a French engineer figures that each of these mills will deliver on an average, 700 hp. throughout the year. The wheel of these mills are to be connected direct to generators encased in light steel shells shaped like a fish to reduce wind resistance.

All generators are to be connected to a common electrical system, and surplus energy is to be used in heating electric boilers the steam from which will be stored in accumulators.

Whatever its practicability, the plan is interesting and if it proves successful, may have a great bearing upon future power development. The one disadvantage of wind as a source of power is its intermittent action. If however, we can devise a suitable arrangement for storing up power at times when the demand is low, we will have overcome the greatest obstacle toward making its use practicable.

However, don't misunderstand us. Even if this scheme proves successful, and is put into practical use we hardly expect to see all of our smokestacks give way to windmills —at least not in our generation.

Double-Acting Diesel Engine Brought Out

New Two-Cycle Double-Acting Diesel Engine Develops 900 Hp. per Cylinder

ONE OF the outstanding features of the Worthington double-acting, two-cycle Diesel engine, which was shown in operation to a group of prominent marine and

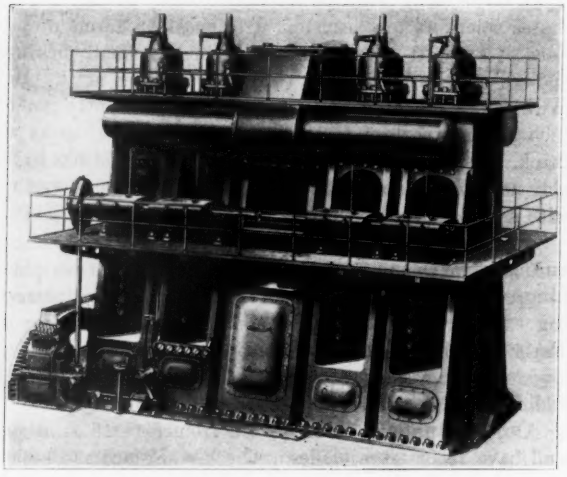


FIG. 1. DOUBLE-ACTING TYPE OF TWO-CYCLE ENGINE AS IT WILL APPEAR WHEN BUILT WITH FOUR CYLINDERS

stationary power plant engineers on Aug. 28 at the Buffalo works of the Worthington Pump and Machinery Corporation, is the cylinder design which permits free expansion as will be noted from the accompanying sectional view. Although the engine shown in operation was only one unit, it is expected that units of three, four, five and six such units will be built. In Fig. 1 is shown a four-cylinder engine as it will appear. The brake horsepower developed per cylinder will vary from about 650 at 90 r.p.m. to 900 at 125 r.p.m.

Conventional lines were followed in the design of the frame and running gear on this engine. The frame is cast of box section; it is entirely enclosed with oil-tight doors suitable for lubrication of all parts under pressure, but separated completely from the cylinder so that no exhaust gas can penetrate the crank case, even should the piston rod stuffing-box leak. A scraping ring arrangement on the piston rod prevents lubricating oil from traveling from the crank case into the cylinder.

On the frame is placed an extension to support the cylinder base, which is bolted directly to the bedplate by means of four tie bolts, relieving the frame of all tensional stresses. The cylinder base is an iron casting which serves several purposes:

(1) As a part of the frame, it serves to transmit the force from the combustion pressures from the top or the bottom cylinder to the main framing.

(2) Connecting on one side to the scavenging air manifold and on the other side to the exhaust manifold, it serves to introduce scavenging air and lead away the exhaust gas from the top and bottom cylinders.

(3) Arranged for water cooling, it serves to introduce cooling water into the jacketed spaces around the top and the bottom cylinders so that the water passing through holes drilled in the bridges between the scavenging air ports and the exhaust ports cools the center part of the cylinder effectively with water at the lowest temperature.

The top and bottom cylinders are alike; each consists of a forged steel shell of a shape suitable to resist the gas pressures. They are made with a substantial shoulder on the outer circumference suitable for securing the shell to the cylinder base by means of a clamping ring, which, in turn, is bolted to the cylinder base by heavy studs, similar to the cylinder head studs in engines of conventional design. Into this steel shell is pressed a cast-iron liner, which contains, at the open end, the ports for the introduction of scavenging air and ports for the outlet of exhaust gas. The free end of this liner rests on a heavy flange projecting inside the center bore of the cylinder base, in which bore the upper and lower cylinders are guided, thus securing perfect alinement. Around each cylinder is placed a light jacket of cast iron bolted to the top end of the cylinder and guided in the clamping ring against which it is tightened by means of a stuffing-box with gland.

With this arrangement of cylinders, it will be seen that the top and the bottom end of the double-acting engine is really two independent single-acting cylinders. The cooling water is introduced in the center of the cylinder base and moves upward through the top cylinder jacket and at the same time downward through the bottom cylinder jacket, regulated at the two outlets with independent valves. The two ends are entirely free to expand from the clamping ring and toward the hot end of the cylinder where combustion takes place and each cylinder end has its own independent set of ports for air and exhaust.

The top cylinder has one fuel valve, the bottom end two fuel spray valves furnished with suitable nozzles for directing the jet of fuel-air mixture. The bottom spray valves are so arranged that the charge does not impinge upon the piston rod.

In a similar way, the piston is built up of two single-acting pistons, each resting on a flange on the piston rod

to which it is secured with a number of heavy bolts. The center part of the piston consists of a sleeve in halves, located on the piston rod by recessing, leaving the two ends free to expand. The piston heads, which are of forged steel, are shaped as deflectors on the air side but on the exhaust side are shaped to allow an easy outlet for the exhaust gases.

Valve motion is designed on conventional lines with one cam for each fuel spray valve. Each valve lever oscillates round an eccentric on the fulcrum shaft, which can be turned through a small angle by hand for reduction of the valve lift at low speed. The cams are symmetrical and can be used for running in both directions by rotating them through an angle of 34 deg. in relation to the main shaft.

Scavenging air can be supplied to these engines either from a displacement pump, driven most conveniently by the engine itself, or by a turbo blower, driven preferably by a d. c. electric motor directly if obtainable in such speeds or through gearing.

Water for cooling purposes is supplied by a pump which is operated by a connection from the crosshead as shown in Fig. 2. In addition to the cooling water for the cylinder head jackets and the exhaust jacket, the piston is also cooled. Water flows up to the piston through the piston rod.

Present tests on the engine have shown a fuel consumption of 0.41 lb. per b.hp. with a full load of 700 hp. on the engine at an operating speed of 100 r.p.m.

Behind the decision of the Worthington organization to go into the development of a double-acting type of two-cycle Diesel engine are a number of interesting factors.

Four (stroke) cycle engines accomplish their combustion cycle in four strokes, of which two are used for compression and expansion, the other two for scavenging. If the engine is single-acting, we have in 90 revolutions 45 power strokes, the displacement of which determines the power capacity of the engine.

Two (stroke) cycle engines accomplish their cycle in two strokes but set aside about 22 per cent of the strokes for scavenging, during which period the exhaust takes place and fresh air is blown in. If the engine is single-acting, we have in this engine, during the same time, 90 power strokes, each of which gives 78 per cent of the power produced by the four-cycle engine, if the rate of combustion is the same in both cases.

If the engines are made to work at both ends, the number of power impulses will be doubled but due to the area taken up by the piston rod, the displacement of the bottom end stroke will be somewhat smaller than the top stroke, namely 90 per cent of it.

This was the principal consideration that induced the Worthington Pump and Machinery Corporation to undertake the development of the double-acting, two-cycle engine as the one in which the running gear is used to its fullest extent and which would be advantageous for these conversions. An engine of this type, however, has other attractive features which are worth mentioning here.

(1) All the principal bearings of a single-acting, two-cycle engine are exposed always to a downward thrust, making their lubrication less efficient than it would be if the pressure changed in direction and so allow the oil to enter more freely between the working surfaces. In the double-acting two-cycle engine the pressure alternately changes direction and is divided between the top and bottom shells approximately in even proportion.

(2) In all single-acting engines the acceleration and deacceleration of the moving masses is, to a large extent, taken care of by the running gear but in the double-acting, two-cycle, the acceleration is always effected by combustion pressure while the deacceleration is accomplished by compression of the next charge. This condition produces smooth running and the load on all bearings as well as the friction is reduced.

(3) Double action doubles the power of the units that can be built with engine parts of reasonable size and weight, convenient for overhaul and handling and with cylinder dimensions within safe limits as regards heat stresses.

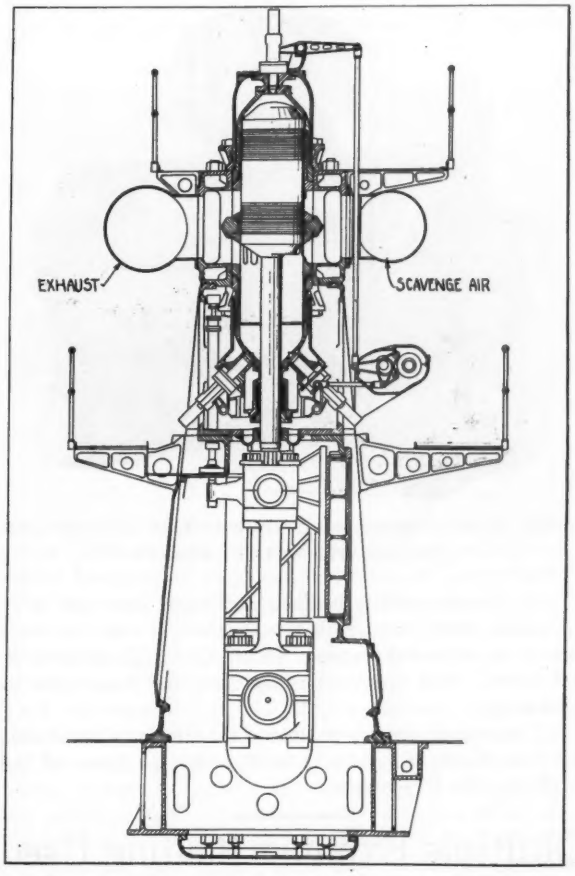
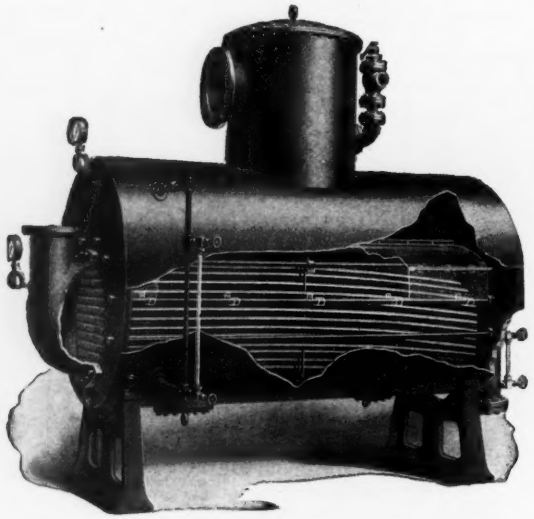


FIG. 2. CYLINDER IS MADE UP OF TWO MAIN PARTS HELD BY RETAINING RINGS

It is the problem for the designer to obtain these advantages without introducing new difficulties found in previous designs. This has been one of the principal aims with the Worthington engine. It has been accomplished by making the double-acting cylinder as two single-acting cylinders on the common frame but entirely independent of each other as regards scavenging and exhaust ports, cooling system and expansion. Similarly the piston, which really consists of two single-acting pistons secured on the same rod but each with its own set of rings, its own cooling space and full freedom to expand.

Bent Tubes Facilitate Cracking Scale in Evaporator

SELF-SCALING is said to be facilitated in a new evaporator, recently placed on the market, through the use of bowed tubes. The motion of these tubes, due to temperature changes, causes the accumulated scale to crack off. Other features are: Fully submerged tubes, giving maximum efficiency of heating surface, preventing superheated vapor and the formation of corrosive gases; heating surface sloped for free drainage of steam; and a tube bundle consisting of a series of independent vertical sections which may be removed separately for inspection.



BOWED TUBES DISTORT WITH TEMPERATURE CHANGES AND ACCUMULATED SCALE CRACKS OFF

In this evaporator the shell and vapor dome are built of welded steel plate, with tube headers of cast iron into which are expanded seamless, drawn Admiralty tubes which are bowed. The steam enters the tubes and evaporates the raw water.

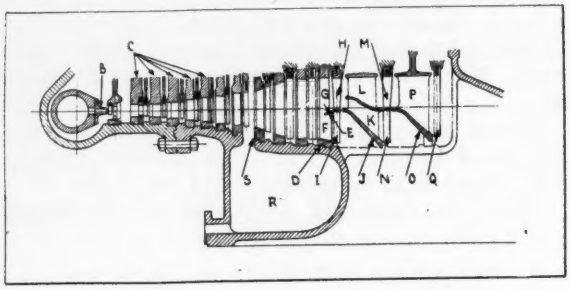
This evaporator is a product of the Griscom-Russell Co., of New York City, and is built under the name of the G-R Bentube Evaporator.

Multiple Exhaust Blading Used in English Turbine

ONE OF THE problems of turbine design is due to the fact that the maximum output for which a turbine running at a given speed and of ordinary design can be built is limited by the permissible length of the blades which is adopted. The first blade length having been fixed, the output is then limited by the quantity of steam which can be passed through the blading at reasonable velocity, and an increase in rating beyond that which corresponds to this steam capacity is only gained, in a turbine built on ordinary lines, at the expense of a higher steam consumption.

In solving this problem the Metropolitan-Vickers Electrical Co. of England has developed a design which uses a system of multiple-exhaust blading which is said to increase the output without any sacrifice of reliability. The design was first announced about 2 yr. ago, although the first installations have been made comparatively recently.

In turbines which are provided with this multi-exhaust blading the steam enters the machine, as will be noted from the illustration, through nozzle boxes and nozzles, B, and passes through the successive stages, C, in the ordinary way until it reaches the special diaphragm, D, where the steam is divided into two parts by the annular ring, E, in the diaphragm. On passing through the outer annulus, F, the steam is expanded down to condenser pressure, the shape of the diaphragm at this point being suitably designed, while in the inner annulus, G, the steam passes without appreciable expansion through suitably formed guide blades. Opposite this annulus, G, is the inner portion of the row of moving blades, H, which are proportioned to expand the steam on the reaction principle, and the steam then reaches the diaphragm, J, which has two distinct annular parts; the part, K being shaped to enable the steam to expand to condenser pressure, while the inner part, L, passes the steam on without appreciable expansion to suitably shaped moving blades, M, where work



ARRANGEMENT OF MULTIPLE EXHAUST BLADING AND BUILT-IN FEED WATER HEATER

is performed by reaction. The steam then passes to another diaphragm, O, where it is finally expanded over the full length of the blades Q down to the condenser pressure.

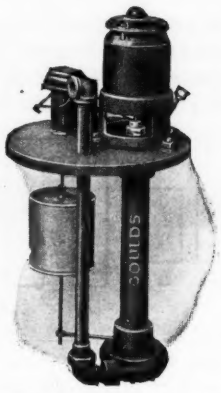
This arrangement enables large outputs to be obtained at high speeds without the use of blades having excessive lengths or large diameter discs. The result is attained by expanding a fraction of the steam in the later stages to full condenser pressure, while the other portion is dealt with in a succeeding stage. The number of the exhaust stages depends upon the particular conditions to be dealt with. Owing to the difference in pressure which exists between the inner and outer ends of the annular passages, a small leakage of steam takes place through the clearance spaces between the guide blades and the corresponding moving blades; but when the large volume of steam at this portion of the turbine is taken into account, this leakage is, comparatively speaking, insignificant.

In the sketch, R, is a surface feed heater through which the condensate is passed, and the steam surrounding the tubes, which are not shown, is drawn from the low-pressure stage of the turbine through an annular port, S, where there is a vacuum of about 22 to 23 in. The condensed steam and non-condensable gases are withdrawn from the heater, R, through a port and after being cooled are discharged into the condenser, with the result that the latent heat in the steam is recovered after it has done a large amount of work in the turbine.

Centrifugal Sump Pump Operates Automatically

ONE OF the new developments of the Goulds Manufacturing Co., of Seneca Falls, N. Y., is a small centrifugal sump pump designed for such work as draining cellars, pits and pipe trenches. The pump is driven by a ¼-hp. motor and the operation is automatic as a float switch is provided which starts the motor when the water level reaches a pre-determined height. In this connection, it will be noted from the accompanying illustration that the pump is arranged for submerged operation so that it is always ready to start.

In the design of the pump a cast-iron volute casing and an open type bronze impeller are used. The pump is suspended by a 2½-in. steel pipe. In order to facilitate the installation of the unit, the pit-cover has been made



CAPACITY VARIES FROM 8 TO 35 GAL. PER MIN. DEPENDING ON HEAD AND MOTOR SPEED

20 in. in diameter so that it will fit the bell of a standard 18-in. sewer tile.

When the pump is driven by a 1750-r.p.m. motor, the capacity is 35 gal. per min. when the head does not exceed 13 ft. If driven by a 1450-r.p.m. motor, the capacity is 30 gal. per min. for an 8-ft. head. For higher heads, the capacities are proportionately reduced.

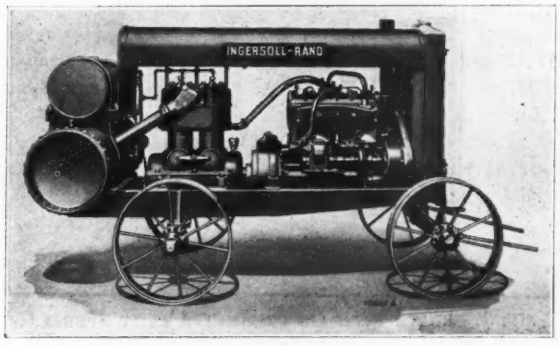
Plant Construction Being Rushed in California

DUE TO the extreme shortage of water for hydroelectric power plants in California, the Southern California Edison Co. is rushing to completion extensions to its steam electric plant at Long Beach, which will house two 50,000-hp. turbine generators, which, together with the three 35,000-hp. generators recently installed there, will increase the capacity of the plant to 200,000 hp. These generators will be served by Westinghouse radial flow surface condensers of 55,000 sq. ft. Condensing water will be supplied to each of the condensers by two 35,000-g.p.m. circulating pumps driven by variable speed motors. Each condenser will be equipped with two motor-driven condensate pumps and two sets of steam air ejectors, one pump and one ejector unit being for stand-by service.

For the Southern California Edison Co.'s steam plant at Power, California, the General Electric Co. shipped from its Schenectady works on Aug. 23 a special train consisting of 22 carloads of electrical equipment including a complete turbine generator unit, together with many accessories. The train contained a 35,000-kw. turbine generator, one 2800-kw. house generator, one 45-kw. exciter, two motor operated field rheostats for main and auxiliary generators and other auxiliary equipment. This shipment was made nine weeks ahead of the original schedule.

Small Air Compressor for Portable Use

SIXTY cubic feet is the piston displacement of small, portable air-compressor which has recently been developed by the Ingersoll-Rand Co., of New York. The idea



PORTABLE COMPRESSOR IS FURNISHED IN A VARIETY OF MOUNTINGS

has been to build a compressor for a moderate cost which would permit its use for work which was formerly considered too small to warrant the purchase of a compressor. It is designed for such work as painting, cleaning and other odd jobs, although it will operate a riveting hammer or a rock drill or two chipping hammers.

In general, the design is similar to the larger Ingersoll-Rand compressors. It is a duplex, vertical compressor, direct-connected to a four-cylinder, four-cycle, tractor type gasoline engine; enclosed construction; circulating water cooling system for engine and compressor with sectionalized radiator, fan and pump; compressor regulator and engine control for reducing speed during unloaded periods; one-piece cast steel frame; sheet steel roof and removable side doors.

Several types of mountings are built including steel wheels and axles; wooden artillery wheels with solid rubber tires and steel axles; on a Ford truck; and on skids for mounting in a car or truck.

BREVARD COUNTY POWER CO., Cocoa, Fla., is making improvements on its plant, having installed a 750-hp. McIntosh & Seymour Diesel engine. They are installing a 22,000-v. high tension transmission line connecting Cocoa with Melbourne. This line includes three substations, one at Cocoa, one at Eau Gallie and one at Melbourne, and electricity will be furnished Melbourne and Eau Gallie from the Cocoa plant. A reinforced concrete building to house the plant is now under construction. The many improvements will cost $150,000.

Plates Held by Springs in New Air Preheater

IN THE plate type of air preheater built by the Prat-Daniel Corporation of New York City, and which has recently been introduced in this country after several years

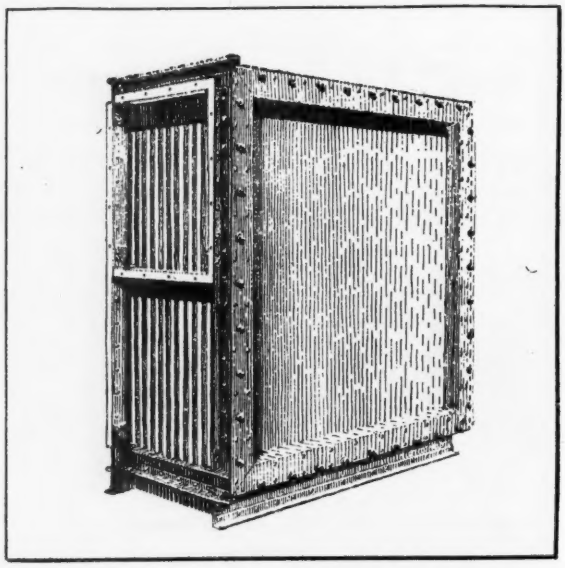


FIG. 1. PLATE TYPE AIR PREHEATER AS IT APPEARS ASSEMBLED

of successful use abroad, the method of holding the plates in alinement is somewhat unique.

As will be noted from Fig. 1, the elements forming the passages for the air and flue gas are mounted in a box-like frame. These elements consist of flat, commercial steel plates, A, (Fig. 2) and distance piece or frames B and C;

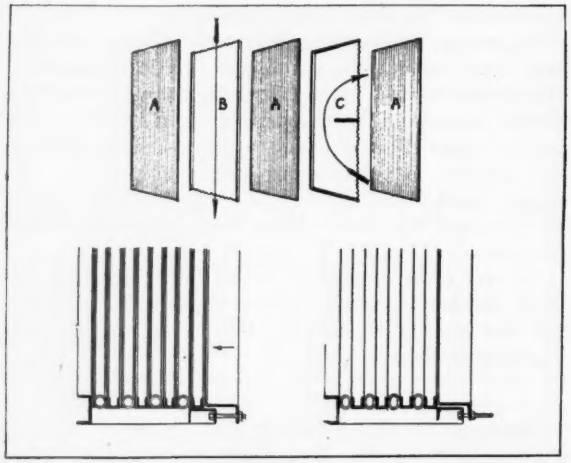


FIG. 2. WHERE OPENINGS BETWEEN PLATES ARE REQUIRED SPIRAL SPRINGS MAINTAIN THE ALINEMENT

the distance pieces are composed of channels and heavy wire spirals. The object of the spirals is to transmit pressure perpendicularly to the edges of the plates when they are compressed together in the frames as shown in Fig. 2. The view at the left in this figure shows the spirals in place before pressure is produced by the tightening screws. These spirals are made of steel of high compressive strength and elasticity and their diameter is somewhat greater than the width of the small channel sections forming the frames.

With this form of construction riveting or welding is unnecessary as the pressure of the springs is sufficient to maintain tight joints. It is stated that no trouble has been experienced due to the effect of high temperature on the springs. This design enables the user to replace plates without difficulty.

Another feature of the "Thermix" heater, is that it can be applied to all types of boiler installations as the flow in the gas circuit can be arranged to suit any particular layout. Figure 3 illustrates four methods of circulation which have been adopted in some of the installations made.

Since the plates in this heater are No. 10 B. W. G. and are spaced from ¾ to 1¼ in. apart, the efficiency of heat transmission is said to be unusually high. Cleaning is taken care of by the use of damper deflectors placed at the inlet to the gas sections. The function of these deflectors is to produce an accelerated gas velocity which will carry away the soot. In some installations arrangements have

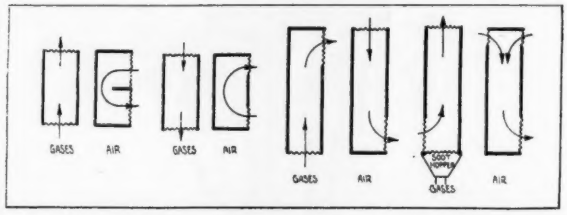


FIG. 3. ARRANGEMENT FOR AIR AND GAS CIRCULATION MAY BE VARIED TO SUIT DIFFERENT INSTALLATIONS

been made to use compressed air. Frictional resistance to gas flow amounts to 2 or 4 in. of water. This increased draft requirement amounts to about 0.5 per cent of the total steam produced, in the added power required for draft fan operation. It is said, however, that this is made up in a drop of 12 deg. in flue gas temperature, which is only a small part of the possible gain through the use of air preheaters.

New 200,000-Kw. Station for Philadelphia Is Under Way

PRELIMINARY work on the new 200,000-kw. Richmond station of the Philadelphia Electric Co. is now under way. The contract for the erection of the station has been awarded to Stone & Webster who will let the subcontracts as agents of the Philadelphia company. Plans for the station have been prepared by the engineers of the company under the direction of W. C. L. Eglin, chief engineer. The architect's plans were drawn by John T. Windrim.

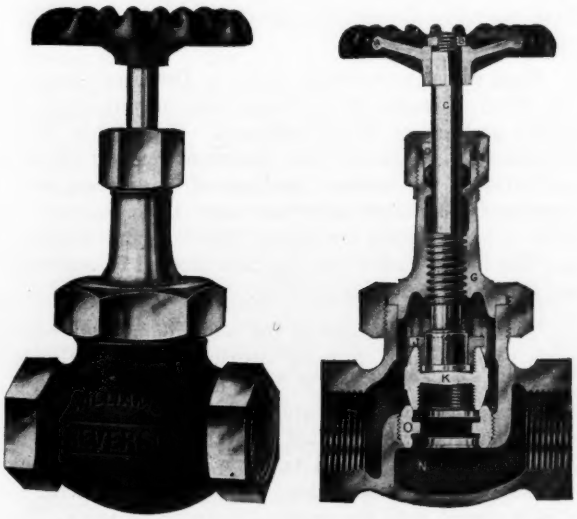
This plant is to be built on a tract of 61 acres located above Erie Ave., and adjacent to the Delaware River. Present plans call for an installation of four 50,000-kw. units although the ultimate capacity is expected to be made up of three such sections, or a total of 600,000 kw.

One building of structural steel and reinforced concrete, divided into three main sections, will house the ultimate station capacity. This building will be 929 ft.

long by 600 ft. wide when it is finally completed. At present only the first section is to be erected. Each main section will be divided into three parts to make up the boiler room, turbine room and switch room. The total space in the generating plant is estimated at 1,388,600 sq. ft. The boiler house, which will be four stories, will contain 706,000 sq. ft., while the turbine house and the switch house, both of which will be three stories, will have 255,600 sq. ft. and 397,000 sq. ft. of floor space respectively.

Disc and Seat Are Reversible in New Valve

IN ORDER to increase the useful life of valve parts, the D. T. Williams Valve Co., of Cincinnati, has recently brought out a line of valves in which both the seat and disc are reversible. Referring to the illustration it will be noted that the disc is fastened to the stem by means of a bronze locknut J. When the hub is removed it is a simple operation to unscrew the locknut and reverse the disc. The seat is removed by inserting a flat, or square, bar which engages the seat lugs, shown at O, when the unscrewing movement begins.



REGRINDING IS ACCOMPLISHED BY REMOVING THE HUB PINNING THE DISC, APPLYING ABRASIVES AND TURNING HAND WHEEL

It will be noted that a bronze packing nut, E, and a brass packing gland, D, are provided. The valve may be repacked while under pressure by turning the handwheel back as far as it will go and then removing the packing nut and gland. There is sufficient room, however, between the handwheel and the hub, G, to permit packing the valve when in the closed position.

In this valve the hub, G, is secured to the body by a bronze union ring. This is said to facilitate regrinding as well as easy access to the valve body and it also provides a joint which is immune to thread corrosion. When regrinding, this union ring is loosened, the disc K is pinned to the stem through the hole provided and, after abrasive has been applied, the disc is rotated by means of the handwheel, the body, G, serving as a guide.

This line of valves is made in various styles such as globe, angle, cross and check types. It is also made with bronze bodies, known as the Reverso, and in iron bodies which are known as Iroverso.

Insull Buys $88,000,000, Corporation

Announcement was made on Aug. 30 of the sale by Joseph H. Brewer and his associates of Grand Rapids of the American Public Utilities Co. to a syndicate headed by Samuel Insull, of Chicago, and his brother, Martin J. Insull, the Mid-West Public Utilities Co. and allied interests.

The sale of control of American Public Utilities Co. carries with it control and management of properties having a total investment of $88,000,000. The price paid by the Insull interests has not been given out.

Control of American Public Utility Co. carries with it through ownership of the common stocks of those subsidiaries, the control of the Holland Gas Works of Holland, Mich.; the Albion Gas Light Co. of Albion, Mich.; the Utah Gas and Coke Co. of Salt Lake City, and the Central Indiana Power Co. of Indianapolis, which in turn controls the Merchants Heat and Light Co. of Indianapolis; Northern Indiana Power Co., Wabash Valley Electric Co., and Indiana Electric Corporation.

News Notes

THE 13TH ANNUAL Safety Congress of the National Safety Counsel will be held in Louisville, Ky., Sept. 29 to Oct. 3. The session of particular interest to the power plant industry will be held as a joint meeting with the Public Utilities and Electric Railway sections on Wednesday morning. The papers to be presented at that time are: The place of the Electric Railway in community safety extension, by L. H. Palmer of the United Railway and Electric Co., Baltimore; instruction and observance of safety rules in station and substation operation, by Homer Niesz, Commonwealth Edison Co., Chicago, Ill.; some high lights on the highway traffic problem, by R. O. Mason, Philadelphia Electric Co.

SANFORD RILEY STOKER Co., of Worcester, Mass., has recently purchased the plant, assets and good will of the United Machinery and Manufacturing Co., of Canton, Ohio, manufacturers of the Harrington stoker, which is of the traveling grate type and rounds out the Riley Co.'s line of stokers. The plant in Canton will continue to operate under the new owners but the headquarters of the business will be in Worcester. The Riley Co. now has works operating in Worcester, Detroit, Decatur, Ill., and Toronto, Canada, and Canton, Ohio.

THE ASH RECLAIMING Machinery Corporation, 347 Madison Ave., New York, has been formed to market the Kolumbus Ash Separator, which has met with considerable success in Europe. The officers of this company are A. M. Hunt, president and Ellis Miller, secretary.

JOHN C. HEAVEY, who for the last 11 yr. has been chief engineer of the North American Building, Chicago, has opened an office as consulting engineer on combustion problems at 186 N. La Salle St., Chicago.

THE DEPARTMENT OF WATER WORKS, Spokane, Wash., will shortly begin work of enlarging the present pumping plant at Parkwater. Plans tentatively call for sinking two wells 75 ft. in diameter, each to yield 20,000,000 gal. daily from the stream they will tap. This water will be raised by a series at low pressure, intermediate and high pressure pumps of either turbine or reciprocating type. J. D. Hopkins is superintendent and A. R. Colville chief engineer.

Books and Catalogs

ELEMENTS OF STEAM AND GAS POWER ENGINEERING, by Andrey A. Potter and James P. Calderwood; 339 pages, 226 illustrations, size 6 by 9 in., second edition, New York, 1924.

In revising the second edition of this text book, the authors have added much new material and have also brought the illustrations up to date. The original purpose of the book has not been changed, for it still continues to be a clear and concrete statement of the principles underlying the construction and operation of steam and gas power equipment. The main portion of the book is divided into three parts. The first part takes up the subject of steam power and discusses fuels, combustion, theory of steam generation, boilers, boiler auxiliaries, steam engines, steam turbines, auxiliaries for steam engines and turbines, and the testing of steam power equipment. The second part is devoted to gas power and includes a study of the internal combustion engine, fuels for internal combustion engines, gas producers and the various auxiliaries used in connection with internal combustion engine power plants. The last portion of the book treats of the application of steam and gas power to locomotives, automobiles, trucks and tractors.

UNDER THE TITLE "Sizes of Steam Pressure Reducing Valves," the Mason Regulator Co. of Boston, has published a pamphlet giving data of value to power plant engineers. This includes besides the sizes of reducing valves, the saturated steam tables, areas of circles and decimal equivalents of parts of an inch.

MORSE CHAIN CO., Ithaca, N. Y., has just issued three catalogs, entitled a Chain of Testimonials, Power and Its Application from the 17th Dynasty to 20th Century and A Chain of Evidence. These catalogs are extremely interesting reading and bring out clearly the field in modern industry for the silent chain drive.

"HOW TO PREVENT Scalding and Repair Troubles in Shower Baths" is the title of a catalog just issued by the Powers Regulator Co., Chicago. This booklet describes in detail the Powers Shower Mixer which delivers cold, warm or hot water as desired by the operation of only one valve.

EUCLID UTILITY, a bulletin covering the application of motor wheel chain hoists and cranes to various types of industries, is now being distributed by the Euclid Crane & Hoist Co., Euclid, Ohio.

ROSS EXPANSION JOINTS are described in a bulletin recently issued by the Ross Heater & Mfg. Co., of Buffalo, N. Y. This expansion joint consists of a slip tube which is either crosshead-guided or internally-guided and a stuffing-box is provided to prevent leakage. The type of expansion joint is described and the complete dimensions of the different sizes are given.

SCOVILL CONDENSER TUBES is the title of a bulletin published by the Scovill Mfg. Co., of Waterbury, Conn. In this bulletin the complete process of condenser tube manufacture, using both Admiralty and Muntz metal, is described. Some of the tests which are used, such as the mercurous nitrate test, determination of grain size and the hydrostatic test are also discussed.

IN A BOOKLET just issued by the Buffalo Forge Co., of Buffalo, N. Y., is given a review of the use of electric fans for blowing, exhausting, ventilating, cooling and drying. The subject matter is confined to direct connected units including descriptions of small disk or propeller fans, multi-blade type fans, used for heating and ventilating, stoker units, pressure blowers, exhausters and electric forge blowers.

BROWNHOIST BELT CONVEYORS is a 48-page catalog covering good practice in belt conveyor design, which is now being distributed by the Brown Hoisting Machinery Co., of Cleveland, Ohio. Of particular interest to the man concerned with belt conveyor installations is a section of the bulletin on standardized conveyors. With the information given, it requires but a few minutes time to select from the tables the conveyor best adapted to a particular job.

FOUR FOLDERS RECENTLY ISSUED by Dearborn Chemical Co., 332 S. Michigan Ave., Chicago, take up various phases of the problem of water treatment. The first of these describes the Dearborn boiler treatment service; the second takes up the results of analyses of 86 different boiler compounds marketed under as many trade names; the third discusses scale formation, corrosion and foaming; and the fourth covers the Dearborn method of approaching the water treatment problem.

THE MYSTIC ORACLE is the name of an interesting little novelty which is being distributed by the Garlock Packing Co., of Palmyra, N. Y. It consists of a folder, on the inside of which is a cardboard dial divided into segments, on which are printed the various applications for packing. If it is desired to know what packing should be used with any one of these particular applications, the dial is turned until the segment is under an arrow. The folder is closed and a metallic arrow on the front cover automatically turns to the proper answer on a circular chart which is printed on this cover. The novelty may be had by writing to the Garlock organization.

BULLETIN No. 122, just issued by the Morris Machine Works of Baldwinsville, N. Y., describes Morris Double Suction Centrifugal Pumps with horizontally split casing. The construction and operating details of these pumps are fully explained, typical performance curves are given showing the efficiencies and other characteristics of different sizes under various conditions of operation, and the use of these pumps is outlined for handling water, brine, oil, acids, pulp and chemical fluids, and for service in irrigation, drainage, unwatering, filtration, sewage disposal, circulation in surface condensers, and heating and refrigerating systems, domestic water supply, boiler feeding, waterworks and standby service, pressure boosting, hydraulic mining, etc. Several installation and operating hints for centrifugal pumps are also given.